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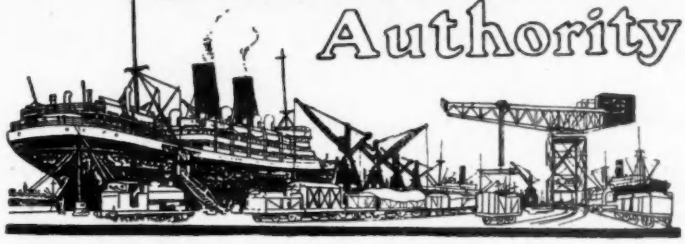
The Dock & Harbour Authority



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Editorial Comments

The Harbours of Guernsey.

Elsewhere we publish an article by Mr. B. C. de Guerin upon the harbours of one of Britain's most interesting and popular islands—Guernsey, the second in size of the Channel Islands which lies 81 miles south of Portsmouth and 30 miles distant from the coast of Normandy.

The island is roughly 15,560 acres or about 24 square miles in area, out of which almost 10,000 acres are under cultivation. While not growing sufficient grain to supply the needs of the population, there is a large export trade of fruits and other garden produce. Parsnips were formerly one of the principle items, but they have been superseded by tomatoes, potatoes and turnips.

There is also an export trade of granite for road surfacing tarmac which is shipped from St. Sampson, but the demand for granite setts for road making has decreased during recent years.

The 45,000 or so islanders, being dependent upon outside supplies for every necessity of life, there is naturally a very large import trade of goods of all descriptions to be handled at the ports as well as the reception of the tourists who visit the island in large numbers during the summer season.

The administration of the Channel Islands and their harbours is different from anything we have in the British Isles and is briefly explained in the article together with an account of the main historical items of interest.

Improvements at St. Peter Port of a major character commenced in the middle of the last century and subsequent developments consisting of piers, quays and roads have been executed from time to time to cater for the ever-increasing export and import trades and influx of tourists who for several decades have been greatly attracted by the natural beauty of the sea, coast and country scenery of Guernsey and the other islands.

The largest ships to use St. Peter Port Harbour do not exceed 4,000 tons gross and it is stated that dredging operations for the first time since 1928 are to be put in hand at a cost of £15,000 to remove a bank of silt which has formed, apparently by the restrictive effect on the tidal scour occasioned by the jetty erected at that date.

Likewise at St. Sampson's Harbour some £80,000 is to be expended upon improvements to the new North Pier and for the purchase of several 5-ton grabbing cranes for discharging imported coal into hoppers.

It is interesting to note that although considerable damage to the ports by demolition works was planned by the Germans, the preliminaries being effected, fortunately no destruction was carried out, owing apparently to the circumstance that no direct attack was made upon the enemy occupied islands by the Allies.

Tide Models.

In this issue is reproduced a lecture delivered by Dr. A. T. Doodson, F.R.S., Director of the Observatory and Tidal Institute, Liverpool, during the Fifth International Hydrographical Conference, which we think will be of value to those engaged in the solution of tidal, estuarial and conservancy problems by the help of models.

The use of models for such purposes has become increasingly popular of recent years no doubt by reason of the accuracy with which forecast results appear to agree with those actually obtained on the sites investigated.

Doctor Doodson, however, is not entirely satisfied that some of the orthodox methods adopted are sufficiently accurate, for example, in simulating the tides by means of the simple plunger, in particular where the model has to do with an open area of water on either side of a deep water approach to a river passing through sand banks for a considerable distance. In such cases he advocates the use of special mechanism for the correct reproduction of all tidal streams, which streams must, of course, have been previously ascertained by careful investigation on the site.

He states that in almost all tidal models of estuaries, rivers and harbours, it is usual to use a distorted scale, in other words, the vertical scale is exaggerated, and that the effects of this upon frictional losses in the resulting model are usually ignored. He goes on to say that engineers have claimed, however, that models do give a close representation of the tides even though the tidal equations are not satisfied section by section, and remarks that a possible explanation may be that the effect of the exaggeration of the vertical scale may produce losses of energy by shock, corresponding in some degree to frictional losses, by the impact of the water upon banks which in the model are so steep as to be approaching the vertical but which in nature are usually gently sloping.

It is generally agreed that in considering, by means of models, bed movement in river channels, some degree of vertical scale exaggeration is desirable or even necessary. Indeed, as Prof. Gibson has pointed out, what is in effect a distortion scale is usual in Nature, since small streams flowing through alluvial ground have much steeper side slopes than large rivers of similar regime in similar ground.

Much research has therefore taken place in this country and the United States of America in respect to proportioning the vertical scale of river models to the horizontal scale and to the choice of the mobile material in efforts to solve the problems of friction, bed movement and turbulence.

It is of course established that claims as to the accuracy of forecasted results obtained by tidal models are well founded, for

Editorial Comments—continued

example, to take only two cases, the results obtained in Liverpool Bay by means of model tests and the astonishing accuracy of the laboratory predictions of 1932-1935, fulfilled at the Port of Rangoon. It may well be, however, that an even greater degree of accuracy might be attained by closer attention to the points raised by Dr. Doodson, and we agree that there is need for more exhaustive examination and experiment to determine precisely how and when any omission to take into account the frictional term is counteracted in the model.

Dr. Doodson suggests that hitherto too many things have been attempted in one model. While this may be true in some cases, it must be observed that in most harbour and estuarial models the problems to be solved are chiefly concerned with the effect of tides upon the beds of the various channels and the means whereby siltation and erosion can be eliminated.

The second half of the Lecture deals with a totally different kind of model which gives electrical representation of tides and streams in a channel. This is the method and apparatus designed by Dr. Joh. Van Veen, Chief of the Research Bureau for Tidal Rivers in Holland.

This method of approach to the problem may be new to many readers and the whole of the subject matter is therefore given intact.

It is not suggested that the electrical model should dispense with either mathematical calculations or the construction of a water model, but rather should be used as a check upon both.

In connection with the studies of Tidal Models we would draw our readers' attention to articles on " The United States Waterways Experiment Station at Vicksburg," and " The Use and Validity of Models in Harbour and Estuarial Investigation," which appeared in the July, 1944, and Sept., 1946, issues of this Journal.

The whole subject is controversial and we hope that Dr. Doodson's lecture will prove of considerable interest to our readers and that they will be prompted to forward to us for publication, for the general advancement of the science, any information, data and experience they may have upon the subject.

In conclusion, we would add that it has been said that " river models are a valuable aid to engineering skill, which, however, they can never replace."

Port Development and Construction in the U.S.A.

The Report under the above heading printed on another page will, we think, be of great interest to our readers, for it gives a brief sketch of the activities of the members of the Port Development and Construction Committee which is a sub-committee of the American Association of Port Authorities.

From the Report a general idea may be gained of the work of the Association in the field of engineering relating to planning and construction of new port works. It will be seen that the ultimate aim of the Association is the production of a Code of Good Practice for the purpose of assisting Port Directors, Port Engineers and others concerned in the creation and administration of Port Terminal facilities which will be incorporated in a Year Book or Manual revised and brought up to date annually.

The methods adopted for arriving at the best practice are explained and appear to have been carefully thought out.

The American Association of Port Authorities has of course many other activities besides engineering, some of which appear to be comparable with those of the Dock and Harbour Authorities' Association of the United Kingdom. We are not aware, however, that the latter has any activity on the basis of the terms of reference of the Port Development and Construction Committee of the American Association.

The maintenance and development of the Rivers and Harbours in the U.S.A. are under military jurisdiction and control and in other respects are run on lines somewhat similar to those pertaining to the Port Trusts of this country.

Since the British National Transport Bill was passed by Parliament, the organisation of the ports of both countries may be said to be on a National basis. It may be said that up to that date, except for the war period when they were administered by Government Departments, the ports of the British Isles have been more or less in open competition with one another and therefore that this fact has mitigated against the otherwise desirable practice of the pooling of knowledge and experience.

We are aware, of course, that many purely technical port problems of reconstruction and new works are publicised and discussed through the media of the various Engineering Institutions of this country but this we submit does not go far enough and neither does it cover the entire field of Port engineering and working.

Now that we have our Ports, Harbours, Inland Waterways and Railways nationalised, it is to be hoped that some method of close co-operation between them and the cities and areas in which they are situated will be found whereby all the diverse interests will be served and all technical knowledge and experience will be shared. In this respect, it occurs to us that, as in America, this country has already an organisation in being and we suggest that the scope of the activities of the Dock and Harbour Authorities' Association should be considerably broadened to embrace such matters as are covered by the terms of reference of the Port Development and Construction Committee of the American Association of Port Authorities, which are set out at the head of the Report already referred to above.

Colour Painting Contrasts in Dock Sheds and Warehouses.

Colour painting in industrial factories and the like is now widely practiced both here and in the U.S.A. It has been amply proved that the proper use of colour for internal decoration coupled with scientific artificial light can transform a dreary and drab factory or office into a pleasing place of work with considerable benefit to the health and well being of the staff employed therein which tends towards increased production and a raising of morale. There is also less fatigue and consequently less incidence of accidents.

In the article contributed by Ernest A. Dench some details are given of the line of approach in the U.S.A. to the subject of colour painting at Marine Freight Terminals or as they are known in this country—Ports and Docks.

While we understand that paint technologists, chemists, physicists and psychologists, working with the Paint Research Station and the British Colour Council have drawn up a basis for colour schemes for factories and offices, we have no information that anything of a like nature has been planned or attempted for use in dock sheds and warehouses and port premises generally.

The need for some such research appears to be established.

Clyde Area Visited by Members of Docks Executive.

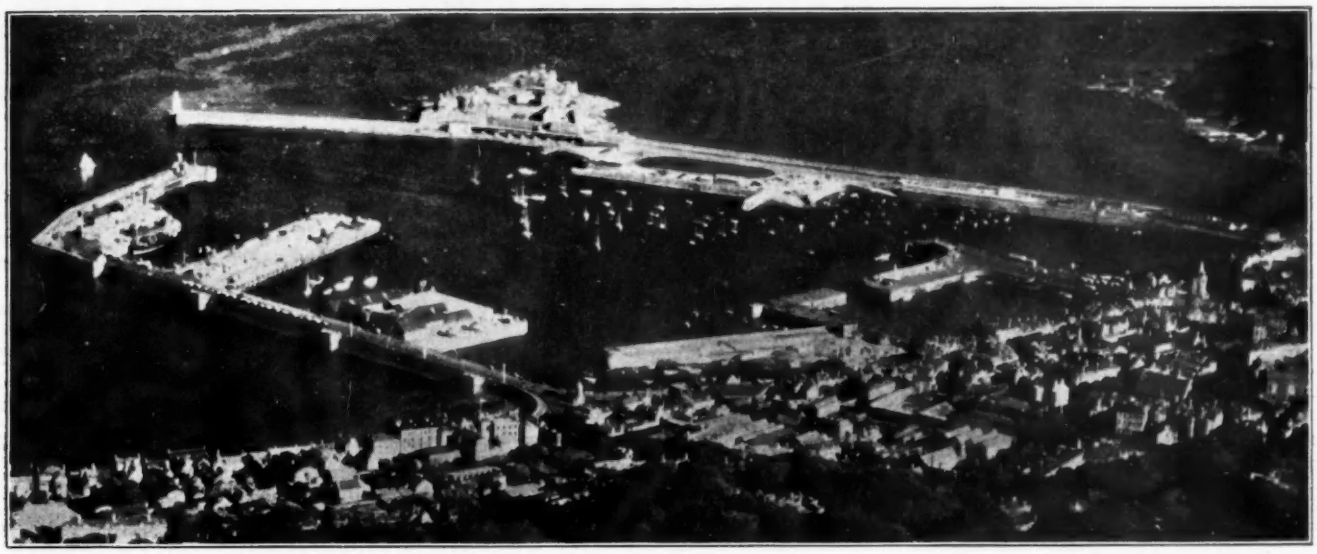
During the middle of last month, members of the Docks and Inland Waterways Executive of the British Transport Commission visited the ports of Glasgow, Greenock, Ardrossan and Ayr for the purpose of consulting with the port authorities and representatives of other interests concerned with the operation and use of certain Scottish ports and docks.

This visit is of considerable interest to all other United Kingdom ports, as it was the first of a series of visits which the Executive will make in carrying out their duties under Section 66 of the Transport Act, 1947. This Section provides that the British Transport Commission (which has delegated the duty to the Docks Executive) shall keep the trade harbours under review, with a view to determining, after consultation with the Minister of Transport, whether the scheme-making powers conferred by Parliament should be exercised with respect to any trade harbour or group of trade harbours.

Humber Ports Grouping Scheme.

In view of the foregoing, the recent announcement by the Docks and Inland Waterways Executive that Mr. A. S. Finnis has been appointed to the position of Chief Docks Officer, Humber Ports may have added significance, as this is the first appointment to be made bringing a group of ports under one control.

The new arrangement means that as from the 1st January, 1949, the ports of Grimsby, Immingham and Hull will be treated as one entity, and vessels can be diverted from one port to another. This will be quite satisfactory so long as there is sufficient trade to keep all three ports busy, but in the event of fewer ships visiting the ports much careful planning will be required to avoid a recurrence of the difficulties which attended the old competitive system. The working of the new organisation will be watched with interest and we hope it will be attended with success.



Aerial View of St. Peter Port and Harbour, Guernsey.

The Harbours of Guernsey

By BASIL C. de GUERIN.

Early History

IT is only natural that the Channel Islands, which had been inhabited for at least a century before the conquest of England by their Duke William in 1066, should have had some kind of harbours in which to shelter the boats of their fishermen.

The first recorded mention of such ports as there were is found in the reign of King John (1199-1216), when he specifically ordered the appointment of " custodes portuum " or " guardians of the havens," these apparently being the islands' first harbour masters.

Constructional work is definitely mentioned by Edward I when, in 1275, he granted certain dues for the erection of a sea wall at Guernsey, and again in 1305 for repairs to the quay. Edward III, in 1331, appears to have inaugurated harbour dues on shipping and merchandise.

It was Queen Elizabeth, however, who, in 1563, gave permission for the local authorities on Guernsey to levy a toll—or " petite coutume "—on the goods of strangers brought to the island, for the erection and maintenance of a pier. This pier, or " chausée," was commenced about 1580, but the levy was not removed until November, 1857.

Camden, in his " Britannia " (London, 1590), describes the haven as " situated nearly at the eastern extremity of the island, where there is an arm erected towards the south, representing a half-moon ".

In 1684 the " Superviseur " of the pier, an annual appointment then, was authorised " to build the north arm," but it was not completed until 1750, and then only by the aid of voluntary contributions from local shipowners and other interested parties.

The harbour thus formed is described as being built entirely of loose mortar, 520 feet in length and 320 feet in width, being an area of 4¼ acres. The entrance was 68 feet wide at bottom and 80 feet at top, with a depth at the entrance of 15 to 16 feet at average neap tides and 23 to 24 feet at spring tides.

In low or dead neaps there were but 12 feet at the entrance and 4 feet only at the quays. The harbour was fully sheltered from 22 points of the compass, partly open on 4 points, and completely open on the remaining six between S. and E.S.E.

It was the custom in those days for the office of " Superviseur " to be " farmed out " annually, which made it a post of importance, from which the present office of " Supervisor " is directly derived.

Between 1740 and 1755 some £3,571 was spent on the north pier and on repairs to the southern arm, and 20 years later the western quays were built. The lighthouse at the south side of the pier heads was first lit on February 28th, 1832.

This harbour was not an unmixed blessing, however, as its floor was covered with rocks, some even at the berths; approach to the quays from land was sometimes impossible at high tides; and it also made a perfect cesspool for over 200 public sewers and private drains which ran into it, so that at low tide all houses in the vicinity had to keep the windows closed, and cholera and typhoid were prevalent.

Agitation for the construction of the present outer harbour began as far back as 1830. The series of discussions, of plans and counter-plans, and of delays would make a story too long to tell here, but one postponement in 1846 was due to the announcement that the Imperial Government intended to erect extensive works to the southward of the island, for the purpose of making Guernsey a naval station, a scheme which never materialised.

It was not until June 6th, 1851, that the States of Guernsey accepted a plan submitted by Mr. James Meadows Rendel, F.R.S., M.Inst.C.E., one of the most eminent civil engineers of the day. This contained seven heads and the total was estimated at £195,000. The resident engineer appointed by Mr. Rendel was Mr. G. F. Lyster.

The foundation stone was laid on August 24th, 1853, but subsequent alterations and additions were voted as the work progressed, during which time Mr. Rendel died. He was succeeded by Mr. Lyster, who in turn resigned in favour of a Mr. Le Mesurier.

In 1862 the Castle breakwater was added, and on March 1st, 1867, the first light shone from its new lighthouse built to the plan of Mr. Peter Le Lievre.

By then the total cost of construction had grown to £360,000, a large sum for a community of less than 40,000 persons, but an investment which has been well worth the outlay.

Subsequent developments during the present century are dealt with elsewhere in the description of the piers and quays.

Compared with St. Peter Port, the Harbour of St. Sampson's is of comparatively modern growth. Actually it was, until some 150 years ago, the mouth of a tidal channel which cut off the northern tip of the island of Guernsey from the remainder, as from half-tide. Although this land was reclaimed in 1806, it

Harbours of Guernsey — *continued*

was some 33 years later before anything was done to create the harbour which had been planned. From then onwards the piers and quays have been constructed and extended, and to-day a further sum of £80,000 is being spent on the development of this industrial seaport.

Politically, the Channel Islands are divided into two "Bailiwicks," Jersey comprising one, and Guernsey and the lesser islands of Alderney, Sark, Herm, etc., the other. Economically, however, each of the latter governs itself and has its own administration.

Thus the harbours of the various islands are controlled individually and have no central organisation for this purpose.

Guernsey possesses two recognised harbours, though there are jetties and piers in various coves around the coasts which are used by fishermen. St. Peter Port is the industrial centre of the island and its harbour therefore the more important, but St. Sampson's is still of considerable economic value as the gateway for imports of coal and exports of granite.

Harbour Administration

Administration of these two harbours is centralised under the executive committee of the island "States," or Parliament, which is known as the Board of Administration. This body functions through its Harbour Sub-Committee and the Supervisor of the States of Guernsey, who is head of the island Civil Service.

Responsible to the latter official and to the above committees is the Harbour Master, Capt. Frank Nicolle, who exercises control over both the island harbours. He is assisted by a Deputy Harbour Master at St. Peter Port, and a Deputy Harbour Master of St. Sampson's, who is permanently stationed at that port.

These officers are responsible for the practical administration of their respective charges and also for the policing of all harbour property. No special force of dock police is needed, as all employees in responsible positions are sworn-in as Special Constables before the island Royal Court on engagement.

Dockers and other workers are to-day members of the Transport and General Workers Union or similar organisations.

The mechanical side of administration at all harbours is the duty of the Maintenance Engineer of the States of Guernsey, who is responsible for the upkeep of all cranes, etc., as well as lighthouses. In addition to those lights and foghorn on the various pierheads of the harbours, St. Martin's Point and the Platte Fougére possess both lights and foghorns, while other illuminated beacons are at Belvedere and on the Platte Rock and Roustel, marking the fairway into St. Peter Port.

The only responsibility of Trinity House on this coast is the Lower Head Buoy, some three miles to the south-east of St. Peter Port, and the Hanois Lighthouse, a mile off Pleinmont Point at Guernsey's south-west corner.

Upkeep of all quays and harbour buildings is the concern of the Civil Engineer of the States of Guernsey who is, incidentally, also responsible for maintenance of the 500 miles of roads on the island.

The two principal industries of Guernsey to-day may be said to be the export of tomatoes and other produce, and the entertainment of visitors.

That the former is out of all proportion to the size of the island, which is only 24½ square miles in extent, is proved by the fact that at the time of writing over 7,300,000 baskets, of 14 lbs. each gross weight, have been shipped during 1948, and it is expected that this total will have been made up to the 7½ million by the end of the year.

Passenger arrival figures for the year 1947 show that 92,914 persons disembarked from Southampton, Weymouth or Jersey at St. Peter Port Harbour, in addition to 8,247 who arrived on the island by air. These figures are expected to be beaten by those of the current year and compare very favourably with arrivals of pre-war which were, by sea only, 56,898 in 1939 and 69,768 in 1938, when the "season" was undisturbed by the outbreak of war.

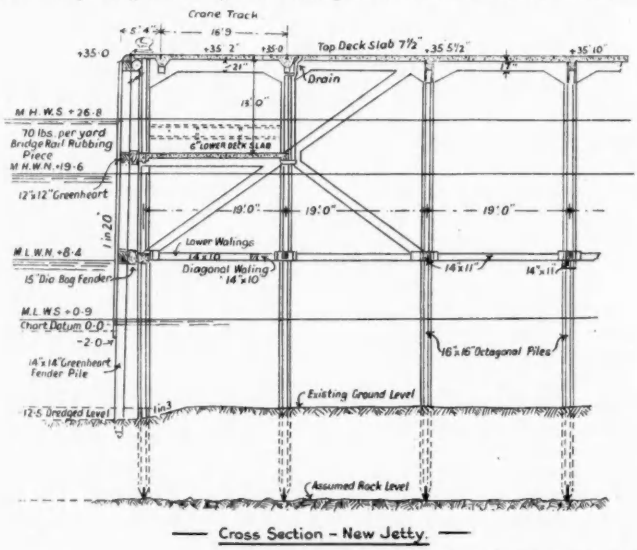
Imports of goods are, of course, very heavy, as the islanders depend upon outside supplies for every necessity of life. This was never so apparent as during the five years of German occupation, when all stocks were completely used up and, at liberation, rehabilitation was necessary for every industry, home and individual.

That this has been accomplished to the satisfaction of not only the 20,000 survivors of those grim days, but of those other 25,000 residents who evacuated before the arrival of the enemy and have since returned to their homes, and to double that number of visitors, is a triumph of organisation in which the Harbour Authorities played a very large part and deserve their due reward of recognition.

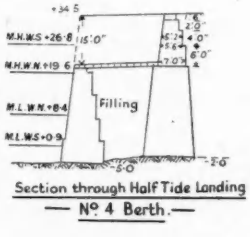
St. Peter Port

Perhaps the most interesting part of the Harbour of St. Peter Port, from every point of view, is the massive bulwark at the northern side of the entrance which is known as The Spur.

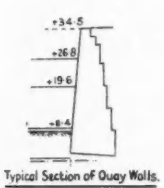
Few of the inhabitants of Guernsey are aware that this structure is actually an island, as it is in fact separated from the remaining harbour works by a vertical joint or line of cleavage of some two inches in width through which the tide flows, the purpose being to restrict within limitations any possible subsidence which might otherwise cause damage to the adjoining pier.



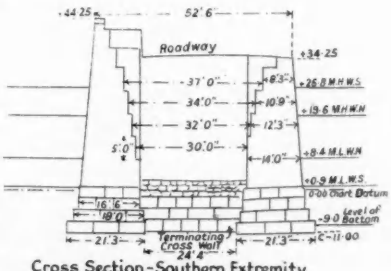
Cross Section – New Jetty.



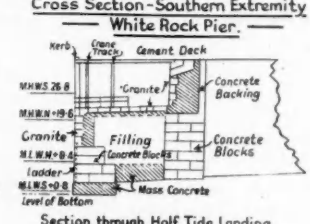
Section through Half Tide Landing — No 4 Berth.



Typical Section of Quay Walls. — St. Julian's Quay



Cross Section – Southern Extremity — White Rock Pier.



Section through Half Tide Landing — St. Julien's Landing

Details of Structural Interest, St. Peter Port.

Harbours of Guernsey—continued

This Spur is built upon a foundation of greenheart piles sunk to a depth which is now unknown but which is considerable. On these piles were placed the large blocks of granite and cement which form the base.

Outer and inner walls of granite were filled in with granite chippings, and for many years the structure was but a shell. Originally designed to be a solid mass, the centre was filled with stones and rubble from local quarries and from building operations in the neighbourhood.

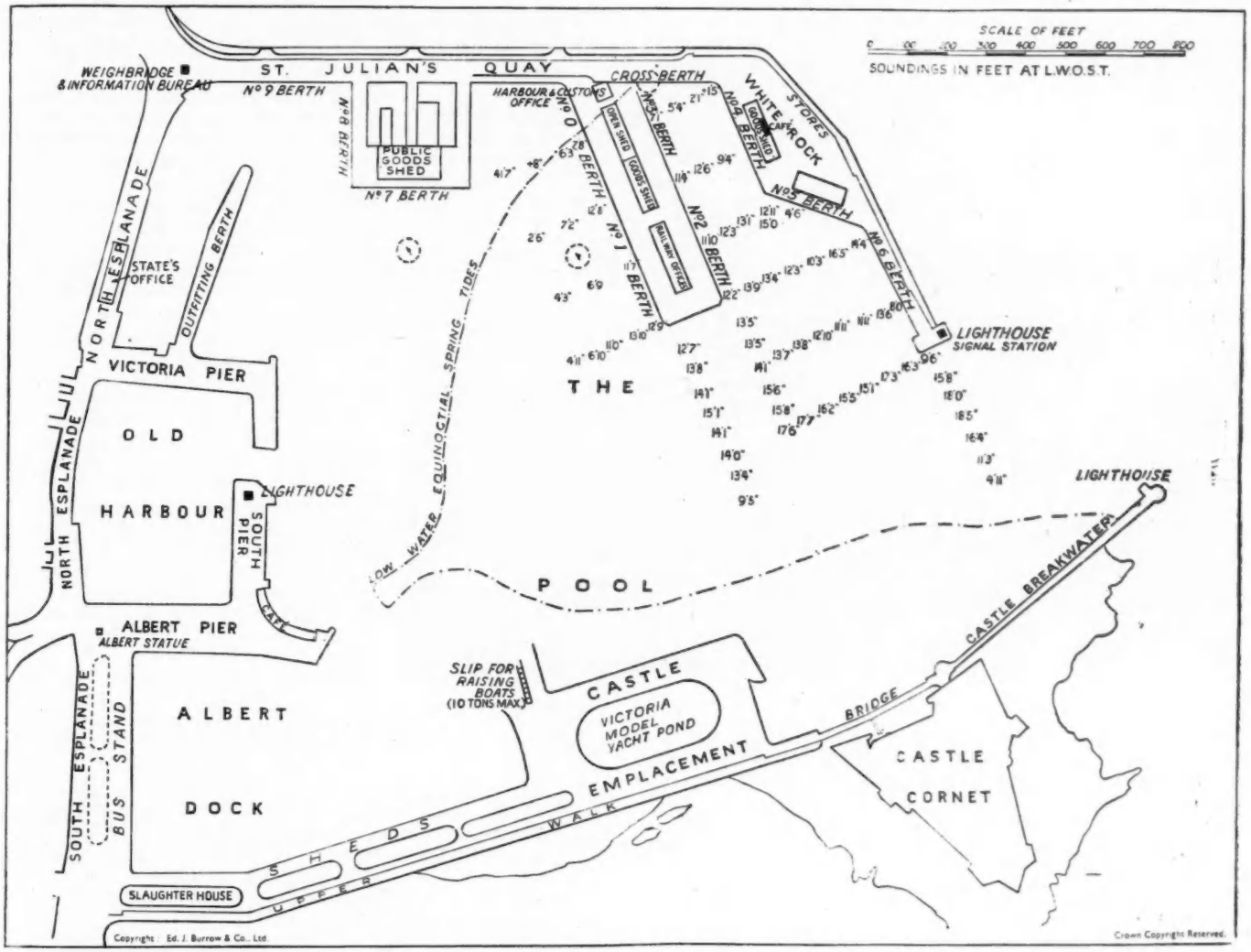
Within a year or two of construction, however, it was found that the weight of the interior was too great for the retaining walls, which threatened to bulge, and so the filling was dug out again and the inner framework strengthened by 3-in. iron ties.

Crevices between the stones and in the foundations allowed the sea to percolate into the interior so that it flowed and ebbed with the tide.

The Germans, during their stay, fortified the Spur very heavily and, in order to support the many tons of reinforced concrete which they laid upon it, once again filled the interior with rubble.

Although much of this superfluous addition to the surface of the Spur has been demolished since liberation, a considerable thickness still remains. As a precaution against weakness developing in the original structure, ties have been bound over the south-west corner, where they also act as fendering should any vessel using the adjacent berth swing against the wall of the Spur. A supporting ledge has also been built along the west wall of this Spur.

A 24-hour watch is maintained at the R.T. Signal Station on the Spur, where all passing and incoming shipping is controlled by lights, loud hailer, and direct communication by radio telephony with ships so fitted, using a wave band of 181 metres. There is also a W.T. station operated solely for communication with the mail-boats on the regular run. Berths available to incoming shipping are indicated by numerals displayed on the east wall of the station.



Outline Plan of St. Peter Port and Harbour, Guernsey. Printed by Ward & Foxlow Ltd

White Rock Pier.

The three landings, the terrace or upper walk, and the eastern wall of the White Rock Pier, are built of massive granite blocks of about three tons weight each, which are "juggled" together with granite pins. On the east side of the harbour outer walls are a number of cellars placed at irregular intervals for the purpose of breaking and absorbing the force of the water, and at the same time to relieve the thrust from inside of the weight of the pier itself.

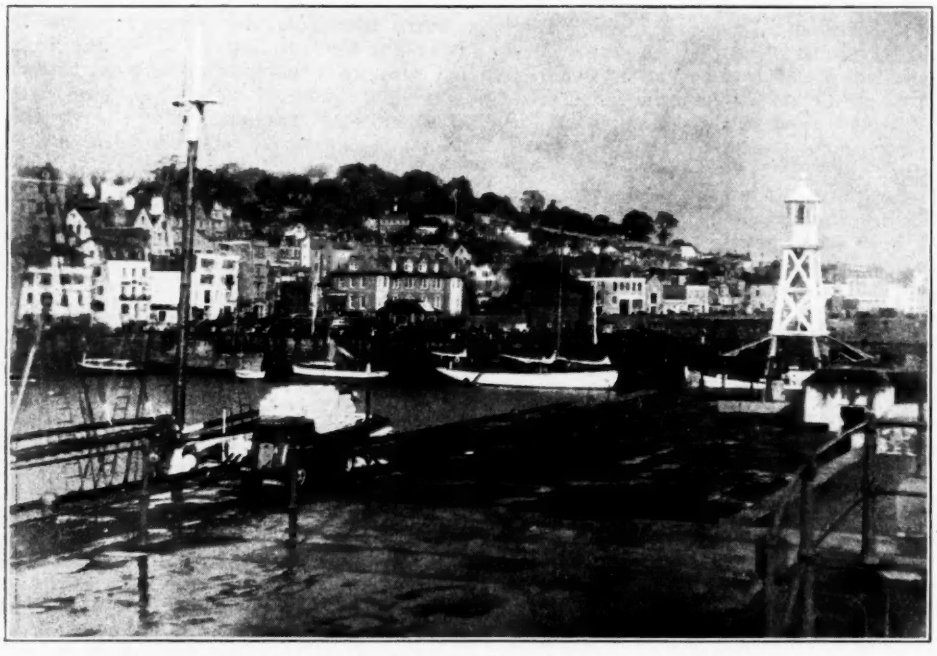
The seaward walls of the St. Julien Pier are also serrated with three recesses which serve the same purpose while providing convenient seating accommodation for pedestrians, and further, access to the open sea by means of flights of steps.

All outer walls of Guernsey's harbours of St. Peter Port and

Harbours of Guernsey—continued

of St. Sampson are built of two walls with a core of hard rubbish. During the construction of the former, the opportunity was taken to create a promenade around the sea-front beyond the limit of the harbour works, for about half-a-mile around Havelet Bay. This entailed excavation through several mounds and hills of considerable size, the rubble and debris from which was utilised in packing these walls.

It is upon such a foundation as this that the present wide roadways and esplanades bordering the harbours are built, but Guernsey has, of course, been fortunate primarily in having at the disposal of the engineers and builders an unlimited supply of such ideal material as her own imperishable granite.



Old Harbour, St. Peter Port, showing Red Light beacon and Victoria Pier.

The northern arm of St. Peter Port Harbour consists of two piers, placed at approximately right angles, the elbow being founded upon the reef formerly known as the White Rock from the fact that it was kept that colour in order to act as a sea-mark and also as a landing place for passengers at low tide.

This White Rock pier is 310 yards in length from the Spur to its juncture with the St. Julien pier or emplacement. The latter, which runs in a due easterly direction is 430 yards long to the St. Julien Weighbridge.

These piers are commodious, having a width of roadway of some 60 feet, in addition to a further 10 feet of terrace and 10 feet of wall, or an overall width of 80 feet. It is not necessary for the walls to have a great depth of foundation, as stability is assured by the width of the adjoining roadway.

Landings and quays for goods and passengers, built into the harbour face of these piers, are constructed of granite blocks supplemented by reinforced concrete. Original uprights or pillars were 2-ft. 6-in. by 1-ft. piles, but due to deterioration by the action of marine animal life, reinforced concrete has superseded them.

Landings Nos. 4, 5, 6 and 7 have tide-level landings awash 6 foot above half-tide level. Of these, Nos. 5 and 6 have still lower landings, which dry out 4 feet above low water at ordinary spring tides. These and other landings have no special protection other than greenheart fendering faced with iron.

Although engineers and architects of a century ago displayed great foresight in estimating the requirements of a traffic which they could not possibly have anticipated, they failed to visualise the development in the art of designing the ships themselves.

Thus when the harbour of St. Peter Port was built, the lower courses of the inner walls were laid of unfaced blocks up to a height of approximately 10 feet. This was of no account when vessels were built with a high rise of floor, but the introduction of the present marine designs necessitated the planing of these irregular surfaces some ten years ago.

Further, these landings were constructed with deliberate "cornering" in order to permit the bowsprits and sterns of vessels to "overlap" one another at right angles. This was a much appreciated innovation at the time, but the increase in the size of ships and the consequent disposal of their holds and below-deck accommodation now prohibits the use of these landings for any vessels greater than their own length, which is from 276 to 300 feet.

Situated at Nos. 2, 3, 4 and 5 berths are commodious goods sheds rented from the Harbour Authorities by British Railways and other Companies trading regularly to the island. Upon the upper deck of that at No. 4 berth is a comfortable and up-to-date restaurant for the use of passengers and workers at the docks. Beneath the terrace of the White Rock pier are recesses used as stores by merchants and shippers dealing principally in chemical manures and other goods for the island horticultural trade.

St. Julien Pier.

It is upon the St. Julien pier or emplacement that the principal activity of the port centres. Here is situated the New Jetty, the construction of which was made necessary some few years after the 1914-18 War as a result of the rapid development of the island tomato-growing industry on the one hand, and the desire of the London & South-Western Railway Co. and the Great Western Railway Co. to provide larger steamers for the Channel Islands run on the other.

After much discussion in the local States, or Parliament, it was decided to incorporate an open concrete pile jetty in the existing outer harbour running in a due southerly direction from its juncture with the St. Julien's emplacement.

This jetty is 600 feet in length by 165 feet wide, with two berths on either side, the terminal cross berth not being used for shipping. The forward half on either side for 300 feet is fendered with sprung greenheart with rubber cushioning between the fendering and the concrete piles. The remainder of the jetty is protected by fixed fender piling. Originally protection was by rope fenders, but these wore out too quickly.

The approach channel to the jetty has a minimum of 12-ft. 6-in. L.W.O.S.T. Piles were pre-cast at the Castle emplacement, on the opposite side of the harbour, and driven over 30 feet down to bed rock. Reinforcing steel used ranged from ½-in. to 2-in., according to position. There is a lower deck 13 feet below pier level, supported by 12-in. by 10-in. struts.

Centrally situated on top deck of the jetty are the offices and warehouses rented to British Railways, with public waiting room, lavatory and other installations, with an open promenade along the entire roof of the building. At the entrance to the jetty are the offices of the Harbour and Customs Authorities, as also the inspection room for examination of produce before shipment to the English markets.

In the small bay to the west of the jetty is the anchorage of the R.N.L.I. lifeboat, "Queen Victoria," with a service station immediately adjoining on the St. Julien Pier. This boat is of Barnett (Stromness) type, 51 feet long, fitted with twin 60 h.p. petrol engines, and of a dead weight of 27 tons, and is manned by a crew of eight men.

Nos. 7 and 8 berths are provided at a pier which, peculiarly, seems never to have received an official name. It was part of

Harbours of Guernsey—continued

the construction of the outer harbour in 1853 and for many years ended in a rough slope to water's edge, which was used principally as mooring ground for punts and small craft. Surmounted by inelegant Black Sheds, it was known as such by generations of inhabitants, but since the destruction of these buildings by fire early in the present century, and their replacement by commodious stores let to fruit-exporting firms and local carting contractors, it has been called the London berth because of the association of the direct line of steamers with that port.

Recently another school of thought has christened this the Cambridge Pier, because an inscription on its only flight of steps —on its eastern side—records that the Duke of Cambridge departed from there on September 22nd, 1862.

The dimensions of this pier are 250 long by 350 feet wide, and its construction is similar to the remainder of the original harbour works. The cross berth, No. 7, occupies the whole of this width, where there is 12-ft. 6-in. of water at half-tide. Its western side accommodates No. 8 berth, with from 7-ft. to 9-ft. at half-tide. These are parts of the harbour of least interest and therefore least visited by the general public.

Incidentally, it is the custom of all regular traders using these and other berths to provide their vessels with floating spar fenders. A unique specimen seen at the berth of the British Channel Islands Steamship Co., Ltd.—that is, No. 8—consists of a spar threaded through some 20 or more motor car tyres, the resilient nature of this making a perfect fender.

The north-western corner of St. Peter Port Harbour is occupied by No. 9 berth, 200 feet long, used for occasional cargoes, such as wood for box-making from Scandinavia or Portugal, and as a mooring ground for private boats and the smaller passenger-carrying craft.

Running parallel to the North Esplanade and sheltered by a breakwater abutting from Victoria Pier is an outfitting berth which is a tidal slope ending in a shingle beach. Originally constructed as a careening hard for sailing ships, it was fitted with rails and cradles, but these have long since been disused and demolished; this berth is now a popular venue for water-polo matches.

Victoria Pier.

The Victoria Pier forms the northern arm of Guernsey's first harbour, now known as the Old Harbour. It is used as a public parking place for private motor cars and upon it is the local government's factory for producing "Thalassol," a disinfectant manufactured from seawater, which is distributed free to the public.

This pier is now used principally for the discharging of timber and coal, though most of the latter is now unloaded at St. Sampson's Harbour. Until comparatively recent times, all coal was unloaded in the Old Harbour by manual labour and frequently the coal boats would be seen lying two or three deep at the piers, with men walking the plank with loaded baskets on their backs, which they tipped into the adjacent stores or into waiting carts.

This was indeed a surprisingly quick method and by it between 400 and 500 tons could be discharged daily. With the introduction of mechanical unloading and motor transport, the work has been transferred to St. Sampson's to avoid dust over the town and to leave accommodation for visiting yachts and small inter-insular passenger-carrying and trading vessels.

There is at present under discussion a scheme to convert the 4¾ acres of the Old Harbour into a wet dock, in order to encourage greater patronage by large yachts.

That part of the North Esplanade still commonly known as the Coal Quay, which forms the western quay of the Old Harbour, is reclaimed land which was built at the time of construction of the outer harbour. In the south-west corner of this were landed cattle imported for slaughter, which were thrown into the sea on arrival and guided up the beach to the adjacent abattoir through Cow Lane, part of which remains to-day. When this pier was built a tunnel was left for the cattle, but this was subsequently filled in on the completion of the outer harbour.

Albert Pier.

The south side of the Old Harbour and the north side of the Albert Dock are formed by the Albert Pier. From this there runs an arm known as the South Pier, on which stands a lighthouse and which, with quay space similar to that on the opposite arm, completes the Old Harbour.

The width of the entrance here is 80 feet, with a depth of water at half-tide of 10 feet, drying out completely at low tide. In this harbour it was common for colliers of from 800 to 1,400 tons dead weight and drawing 14 or 15 feet of water to dry out while discharging cargo. Total area of quay accommodation in the Old Harbour is approximately 600 feet.

No. 5 Berth, White Rock Pier, St. Peter Port.

Upon the curving end of the South Pier are a number of buildings used for storage, office accommodation, cafe, etc., and along the entire length is a terrace and promenade provided with seats. At the south-easterly extremity is a landing stage with a lower deck which is used by smaller local craft on inter-insular runs, as are the adjacent flight of steps, when the tide serves.

Principal users of the Albert Dock are island fishermen and yachtsmen, although oil, petrol and explosives are landed at the southern quay. There are no special reservations for unloading explosives, of which imports were 96 tons in 1947 as compared with 166 tons in 1938, when the island quarries—which are not now working—accounted for increased use.

At the time of its construction, it was intended that eventually the Albert Dock should become a wet dock, and a wall was actually started which was known as the "Broken Wall" for many years after the project was abandoned. The reason for giving up this work was that a fresh water stream percolated through the floor of the harbour just where the foundations would go, and, although modern marine engineering could soon adjust this satisfactorily, the cost would be disproportionate to any advantage gained.

The island abattoir, stores, workshops and sheds for use by the technical and engineering staffs of the local Civil Service, as well as the site of oil and petrol tanks, occupy the centre of the Castle emplacement. The latter forms the southern arm of the outer harbour and commences at the South Esplanade, at a distance of 720 yards from the St. Julien's Weighbridge.

Midway along its length is situated a space of 360 feet wide by 570 feet long, which has been for many years the site of a model yacht pond. The existence of the latter has twice been interrupted, when during the first war it was demolished to provide space for the French "Aviation Maritime," who guarded the

Harbours of Guernsey—continued

island, and again when the Germans occupied the area—and from the damage caused by the latter it has not yet recovered.

In the north-west corner of this pier is a slipway and winch for raising boats not exceeding a maximum of 10 tons, and the immediate vicinity is occupied by yachts when laid up and by the sheds of boat-builders and marine engineers. Slips in the south-west and south-east corners act as spending ways for the tide in rough weather, as does that in the south-west corner of the Old Harbour.

As the Spur of the White Rock is an island of a sort, so is the opposite arm of the harbour mouth, that of the breakwater which juts out beyond the base of Castle Cornet and protects St. Peter Port from the south.

This is due to a gap in the harbour walls, which is made good by a wooden bridge. Originally designed as a ready means of isolation in case of frontal attack upon the Castle by an enemy, it also serves a very useful purpose in providing a safety valve for easterly gales at high tide by preventing the backwash which would otherwise sweep across the mouth of the harbour.

This bridge, which is 300 feet long, is supported on 12-ft. by 8-ft. greenheart posts on granite bases, which will be replaced as and when found necessary with reinforced concrete pillars.

Construction of the Castle Breakwater is of the same type as that of the other outer walls, a double wall with a core of granite and hard rubble. The head and lighthouse are, however, built upon a foundation of solid rock.

From this lighthouse to the junction of the Castle emplacement with the South Esplanade, this arm of the harbour measures 950 yards. Width of the harbour mouth from Castle Lighthouse to White Rock pier head is 600 feet. and minimum depth at L.W.O.S.T. is 17 feet.

The extreme spring range of tide in St. Peter Port and St. Sampson's Harbours is 32-ft. 6-in., which reduces itself during neap periods to approximately 8-ft., when difficulty is experienced by the officials at both harbours, where berths dry out and vessels must await their turn to enter and depart.

The area of 72 acres enclosed by the two arms of St. Peter Port Harbour was by no means clear water when construction was completed. One obstruction in particular was situated almost diametrically opposite the entrance of what then became the "Old Harbour." This was known as the "Road Rock" and was in fact an island at half-tide, which took much effort and many years to remove in view of its proximity to passing shipping. The final dangerous under-water remains were only demolished in the early years of the present century.

The bed of this harbour had also to be levelled and dredged, particularly at the berths. Disturbance of the sand and mud by the propellers of screw and other steamers, especially at low tide, was always a problem to the harbour officials. This was perhaps more so in the days before the jetty was built and mail boats used the present No. 6 berth when the tide was low.

So badly undermined were the foundations of this pier and the adjacent Spur becoming, that a law was made prohibiting any vessel using its propellers within 60 feet of the quayside, all making fast and warping out to be done by bollards and buoys. This law is still in existence.

Future Dredging

Dredging operations have not been carried out since the jetty was built in 1928, but a proposition to carry out this operation again has been before the "States" of Guernsey within the last two or three months.

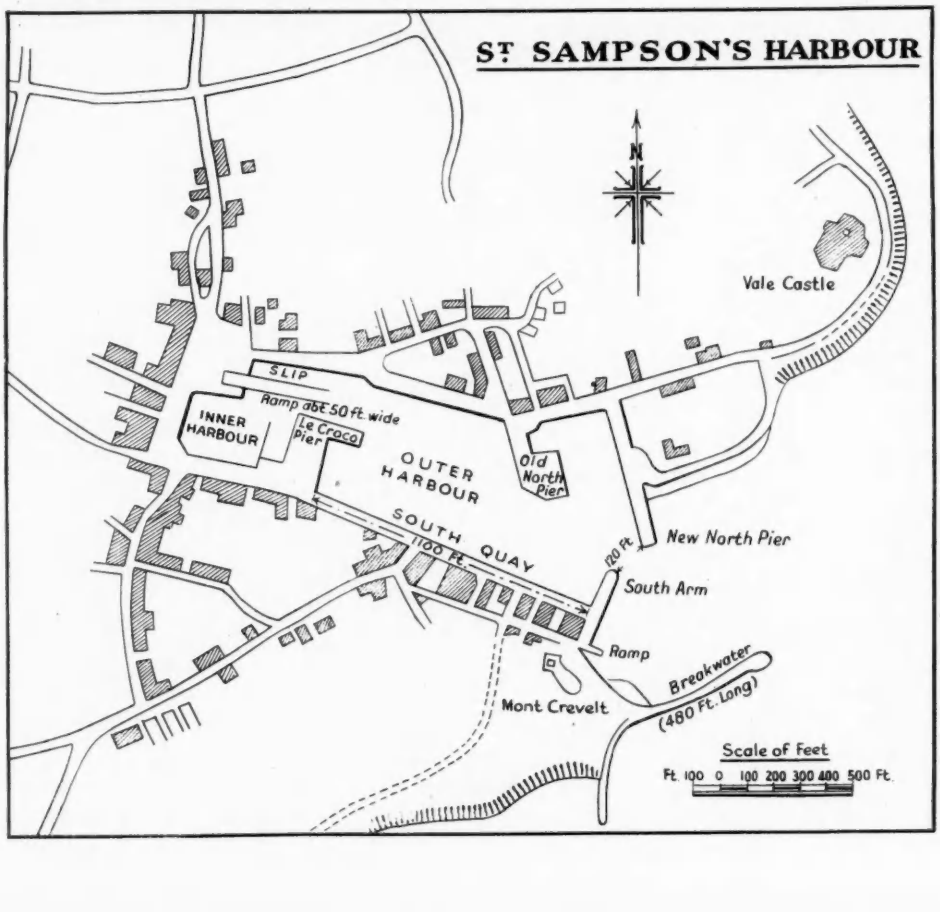
It is stated that during the past 20 years a bank of silt has formed beneath the jetty which, in places, is now 14 feet above the 1928 level of the harbour bed. This is now extending outwards towards berths Nos. 0 and 3, and there is a risk that vessels may suffer damage. This bank is caused by the restriction to the natural scour of the harbour bed by the tide set up by the piles and is steadily increasing. Powerful suction dredgers would be needed to remove the silt which would have to be dumped at sea in hopper barges, and, as suitable equipment is not available in the Channel Islands, contractors will have to be engaged. It is estimated the cost will be about £15,000, but this will be subject to interruptions by shipping and weather conditions during progress of the work.

A diver and his crew are permanently employed on inspection and maintenance of harbour walls, etc., and their services are always available to shipping for minor under-water troubles such as fouled propellers, etc., a facility much appreciated by those compelled to avail themselves of it.

Largest ships to use St. Peter Port harbour, apart from some of the leviathans which brought both joy and amazement to the inhabitants at liberation, are the T.S. "St. Patrick," 3,482 gross tonnage and 306-ft. in length: and the T.S. "Falaise," 3,710 g.t. and 299.8-ft. in length—both of which draw 13-ft. 3-in. They are also fitted with bow rudders.

Nett registered tonnage of commercial vessels into St. Peter Port Harbour in 1947 was 922,271, which was considerably below that for 1939, which was over a million tons.

In addition to trading vessels of all kinds, Guernsey receives visits from many hundreds of yachts during the season, besides being a popular cruising centre for English and French yacht clubs. Anchorage is available in the south-eastern section of the outer harbour, known as The Pool, and no harbour dues are payable by bona fide yachts.

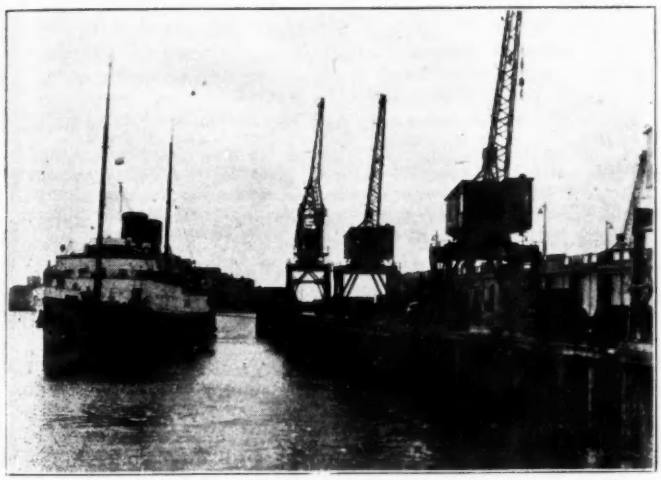


Harbours of Guernsey—continued

A local regulation compels all vessels arriving from ports within 20 kilometres by land or 10 kilometres by sea of regions infested with Colorado Beetle to submit to inspection of crew, passengers, cargo and effects.

Both St. Peter Port Harbour and that of St. Sampson's, three miles further north, are well equipped with cranes, the former having a battery of 16 modern electric cranes by Stothert & Pitt, and Booths, with capacity ranging from two to 20 tons. These have supplanted those driven by steam, which in turn took the place of the hand cranes installed when the harbours were built.

There are five slipways at St. Peter Port, which act as spending ways for boisterous seas as well as landing places. These are at the north-west corner on the outer wall of St. Julien's Pier; in the south-west corner of the Old Harbour; on the north and south sides of the Albert Dock; and in the north corner of Havelet Bay, on the outer wall of the Castle emplacement.



East Side of New Jetty, St. Peter Port.

In addition there is the beach at the Outfitting Berth, North Esplanade, and the cradle slipway on the north side of the Castle emplacement at present rented by Messrs. Motor House, Marine Dept., for yacht building and repairs.

St. Sampson's Harbour

St. Sampson's Harbour also possesses a modern yacht yard which has been created since the last war by Messrs. Guernsey Yacht Yard, Ltd., where construction, overhaul and repairs are carried out, as well as laying-up for winter.

This harbour, which was constructed in 1820 and is subsidiary to St. Peter Port, was formerly of sufficient importance to justify its own harbour master, when the trade in Guernsey granite, which is mostly quarried at the north of the island, was at its height and the quantity shipped totalled 500,000 tons annually.

The total area of St. Sampson's Harbour is 19 acres, with width at pier heads of 120 feet. It dries out at low tide, but has from 8-ft. 6-in. to 10-ft. at the pier heads at half-tide. There are eight berths on the north side and four on the south side, giving 3,000 feet of quay space. Construction of walls and landings is of the same type as that of St. Peter Port.

It is proposed to spend £80,000 on improvements to the new North Pier at St. Sampson's. Orders for three 5-ton grabbing cranes for discharging coal to hoppers have been placed for use on the north side, where the quay is being reinforced with concrete piling. This work is expected to be finished next Spring and the cranes operating in time for the 1949 season.

On the south side are three diesel electric cranes of lifting capacity of 6 tons, with 2-ton grabs. Charges are 1s. 6d. per ton.

From No. 1 berth, south side, which can accommodate vessels up to 150 feet, an oil pipe-line runs for over half a mile to oil tanks at Bulwer Avenue. Although there are temporary oil storage tanks at St. Peter Port Harbour, eventually all fuelling operations will be carried out at St. Sampson's.

Pilotage is compulsory in Guernsey waters, except for naval craft, trading vessels of less than 40 tons gross tonnage, and pleasure yachts. Pilots are stationed at both St. Peter Port and St. Sampson's Harbours.

No history of the harbours of Guernsey would be complete without a word on the German occupation from July 1st, 1940, to May 6th, 1945. In an air-raid prior to their taking over, damage was done to the St. Julien Weighbridge and to road-surfacing, the greatest loss then being the lives of over 30 innocent bystanders.

At intervals during their stay the harbour was visited by Allied airmen, who were aware that it was being used as a submarine refuelling depot, and though one of their depth charges caused havoc among the plate-glass windows of the town, no structural damage was done to the harbour works.

Throughout the occupation every crane and other vital mechanism was mined for demolition in case of attack by an Allied force, but as none came the Germans themselves were made to remove these mines after their surrender.

The happiest day in the life of the present Harbour Master, Capt. Nicolle, who had been removed from his post as Deputy Harbour Master for having aided his own nephew, who landed as a commando, was on the day after liberation when, wearing his uniform again, he took charge of a gang of prisoners of war and put them to levelling the bed of the harbour.

Pier for Damman Port, Saudi Arabia

As briefly announced in the December, 1948 issue of this Journal, a Pier is to be constructed at Dammam Port on behalf of the Arabian American Oil Company. This pier will be approximately 7 miles in length, consisting of a Causeway 5 miles long, a steel piled Trestle 2 miles long, at the end of which a Main Wharf approximately 600-ft. x 80-ft. In addition a Small Craft Wharf is to be constructed at the end of the Causeway in the shape of a box formed with steel sheet piles filled in with rubble, approximately 240-ft. x 60-ft.

The Causeway consists of limestone material quarried on the mainland and then conveyed and tipped into the sea, and the approximate quantity involved will be 500,000 cu. yds. The maximum depth of tipping will be 18-ft. The sides of the Causeway will be pitched with large rocks to prevent erosion due to sea movement, and on top a standard gauge railway will be laid consisting of flanged rails on timbered sleepers laid on graded limestone ballastic.

The Trestle Pier and New Wharf consist of steel piles of " H " section, 14-in. x 14-in., weighing approximately 90 lbs. per foot lineal. These piles vary in length from 45-ft. at the shallow end to 95-ft. at the Main Wharf. The structure above the piles consists of " H " section caps and horizontal beams which are made up of steel members, all prefabricated by the contractors on site; all this fabrication, together with the fixing of caps and beams, will be done by welding. In effect this pier will then be mainly all-welded construction. All piles and other steel members will be treated before fixing with a bituminous paint. The Trestle and Main Wharf have the same standard gauge track, together with sleepers, whilst on the Main Wharf in addition the whole area is timber-decked, on which is placed a carpet of cold bituminous macadam in order to ensure easy movement over the whole area of the wharf. It will be necessary to drive approximately 1,500 piles to construct the Trestle and the Main Wharf.

The Small Craft Wharf mentioned before consists of " Z " type steel sheet piling, approximately 40-ft. long, tied together with steel tie bars.

In order to carry out the construction of the above Pier and Causeway, the Contractors will be providing plant of all types, including Ruston Bucyrus Excavators, Butters' Derricks, Murex Welding Equipment, 10 cu. yds. steel body lorries, and suitable piling frames, semi-automatic hammers and oil-fired boilers which will be erected on floating craft.

Colour Painting Contrasts in Dock Sheds and Warehouses

By ERNEST A. DENCH, New Jersey, U.S.A.

Working visibility is none too good, on the whole, at or near marine freight terminals, which, for geographic reasons, are located where atmospheric conditions—fog, mist, smoke, etc.—periodically reduce natural light to a minimum. Further, sheds and other dock buildings are often close together, resulting in more restriction of natural light, and it is through these congested and often antiquated areas there flows a tremendous amount of cargo.

Inside these buildings the application of the colour contrast painting technique will enable employees to work faster, more accurately, with greater ease, and with fewer accidents.

This desirable accomplishment will be due entirely to the increased light reflectivity of the closely co-ordinated painted surfaces of the ceiling, walls and the floor. One such colour painting combination used in a number of effective applications has a flat white for the ceiling, a flat cream for the walls, a pearl grey for the dado, and a green-grey gloss for the floor.

Ceilings.—White has a light reflectivity of ninety per cent. on these elevated surfaces; the minimum requirement in light reflectivity from a ceiling finish being eighty per cent. Among the whites, " paper white " has the highest efficiency—and ivory the lowest. A few degrees off the beam, so to speak, are canary yellow and cream, each with a reflectivity rating of seventy-seven per cent.

Choice of one of white's close allies—yellow, cream, buff or pale pink—is advisable in any marine warehouse, with a low ceiling. Even blue, which has a receding effect, will convey the illusion that the ceiling is higher than it actually is. A flat or egg-shell paint should be used; a gloss paint produces an eye-irritating glare.

A white which will stay *white* is essential for a high ceiling. Choose a white made of such non-darkening pigments as crytone, albalith zinc sulide and zinc oxide. This type of white will decrease the subsequent maintenance costs.

The greatest gain in light reflectivity occurs when the same paint is permitted to encroach on the wall area to the level where the picture moulding is, or would be in a home or institution.

Structural supports—posts and pillars—physically belong to the ceiling, and so should be painted white. On the other hand, if pillars and posts are in areas used by materials handling vehicles, traffic visibility hazards are present. Alternate yellow and black stripes, up to 4 to 5 feet from the floor level, should adorn such pillars and posts.

Walls.—The goal is a light reflectivity minimum of fifty per cent., provided there are sufficient windows to allow free entry of natural daylight; if not, colour painting must ensure at least sixty-five per cent. of reflectivity. If the work area has a high ceiling, it can be made to appear slightly lower with painted bands. These bands, as they near the upper parts of walls, should be painted lighter than the ones below.

Dado Relationship to Walls.—A sound rule to follow is choice of a colour not over two shades deeper than the one on the wall above the dado. The exception is when materials handling vehicles back up to discharge or take on loads against the walls. Fork and other mechanised trucks operators are likely to misjudge the distance and disfigure the colour painting layout. One marine organisation solved this problem by tarring the walls as high as the most " mountainous " fork truck load. The black of the tarred surface and the other than black of the fork truck loads provided sufficient contrast.

The above case, while an exception to the two shades deeper difference between the dado and upper walls, conforms to the other rule that dado height should dovetail with loaded levels of materials handling vehicles.

Floor Area.—Light rises from a floor painted in a light colour, thus increasing the worker's visibility at his level—the colour of floors is therefore also important. However, a white-painted floor, or the too liberal use of white-painted lines, quickly darkens from heavy traffic, whether pedestrian or vehicle, or both.

A reasonable compromise is an all-white floor in a stippled arrangement. This uses dots instead of lines. One successful application uses both pure white and very light grey as the base colours. This stippling is complementary to the side walls. Another example is that of a marine organisation satisfied with a white floor stippled in spruce brown, with the side wall in light green.

Which brings us to the concrete floor problem—to paint or not to paint? A concrete floor has but a five per cent. reflectivity, but this can be increased to thirty-five per cent. by painting it a medium grey.

Choice of Paints.—The high-reflecting paints retain their whiteness longer than other kinds of paint; they also have the highest capacity developed by chemists to date. Often, too, one coat will do the job of two—and dry faster, causing less interference with waterfront warehouse operations while the colour painting contrast system is being applied.

In glossed paints there are variations, the use of which depends on the kind of reflected light desired or necessary. If light rays are to have the widest possible range or reach, since surfaces reflect light in parallel lines, a high-gloss paint finish is desirable. It is also favoured for walls and ceilings, because of being easier to wash. On the other hand, a high-gloss finish is not capable of producing a soft, diffused effect.

Lighting Links, Natural and Artificial.—One of the major purposes of colour painting is to complement the prevailing amounts of natural and artificial light. When these sources are equal, there is a restful effect on workers' eyes.

Natural light varies according to location. If it comes from the north, a cold blueish tinge is the characteristic. The colour painting complementary is a dark tan. From the south; natural light has a warmish yellow glow or tinge, the painted companion to which is a light blue. Natural light from the west inclines strongly to red. It should be contrasted with green paint. Any part of a building with an eastern entry of natural light receives it in a neutral tinge. It needs a neutral colour complement, of which grey is the best.

Another consideration is the prevailing standard of sunlight, and where sunlight is extremely powerful, brilliant colours in paint can be employed as complementaries.

Whether east, 'west, north or south, or in temperate or subtropical zones, natural lighting attains its greatest brightness in the areas surrounding windows, skylights and open doors. Beyond these areas there is diminished brightness, which reaches the lowest intensity at the most distant corners. In one colour painting test midway through an area where natural lighting commenced to lose its brightness, white as a colour painting complementary proved efficacious, its value being fifty-two per cent. more than yellow and forty per cent. more than grey.

During a critical period of World War II, when production needed to be speeded up, Arthur A. Brainerd, an illuminating engineer, went the rounds of Philadelphia plants engaged on war contracts. He discovered in the majority of the buildings that dingy spots on floors, ceilings or walls, were soaking up the limited amounts of light instead of distributing them to the best advantage.

We now mention an obvious way to increase lighting efficiency, because the obvious is sometimes overlooked in the quest for a remedy. This method is to remove more of the wooden or masonry walls. The object being: more windows as natural light entrances. Equally obvious is the advice to keep existing windows in the building spic and span, and so have them continue to reflect their full quota of natural lighting.

ARTIFICIAL LIGHTING

Summarising in turn the three kinds available:—

Incandescent provides a warmish glow, the proper or appropriate colour painting foil for which is a cool hue found among the greens and blues.

Mercury Vapour has a coldish effect, so warm paint colours among the tans (or a coral) are needed.

Fluorescent is represented by three types, each with a different colour effect. Bluish is the " daylight " type. Yellowish-green (slightly so) is the " white " type. Purplish (slightly so) is a variation of the " soft white " type.

The soundest rule to follow if two or three types of fluorescent

Colour Painting Contrasts in Dock Sheds and Warehouses—continued

lighting are used within the building is, within each circumferential area, to match the colour painting to the type.

Any building in which incandescent, mercury vapour and fluorescent lighting are used on the same floor will get the most satisfactory lighting with neutral colour painting complements, of which certain greys are desirable.

Exterior Effectiveness.—What, then, of the outside areas—the dingy docks, wharves, piers, etc.? They should be brightened up with paint for contrast effectiveness. Traffic lanes definitely segregated with stippled paint lines. Overhead equipment, such as cranes, appropriately coloured at the key spots.

Other adaptations, to outside areas, of the colour painting contrast technique will undoubtedly occur to marine executives from the fundamentals outlined earlier in this article.

Port Development and Construction in the U.S.A.

TERMS OF REFERENCE.

"The Port Development and Construction Committee shall collect the best available technical data relating to the comprehensive planning of harbour waterfronts from an economic and public viewpoint, the general planning of terminal facilities, traffic arteries, recreational and park areas, and the design of marine structures, construction methods, freight handling and marine equipment and related subjects, and shall, upon request, advise members in regard thereto."

The Port Development and Construction Committee, in addition to its normal mission of collecting and disseminating technical data covering the planning and construction of new port works, has undertaken the preparation of an original work on port terminal standards. The latter activity proposes to carry forward the substance of a plan outlined in the last annual report of the committee.

It may be recalled that the committee originally planned to prepare a reference manual in collaboration with the Port Development Section of the U.S. Maritime Commission. It was intended at that time to combine the results of the research work then being done by the Commission with data derived from actual port experience and consulting talent of the members of the Association to produce a reference source. It was felt that there was a need for a reliable code of accepted good practice and that such a work would be of valuable assistance to those charged with the development of American ports.

The curtailment of the port research programme by the Commission resulted in the abandonment of the original plan and the placing of the full burden for the preparation of the proposed manual on to the Association.

The former chairman of this committee, Mr. E. J. Amar, carefully selected the group of outstanding engineers and experts on port development and construction that currently compose the committee. It seemed reasonable that the original objective could be achieved, since much of the data resulting from the Maritime Commission research activities were in possession of the member selected as committee chairman. Mr. R. R. Shoemaker was chosen as vice-chairman.

In May of this year, a preliminary prospectus outlining the subjects to be covered by the proposed Manual of "Design Standards for General Cargo Terminals" was sent to each committee member, together with a check list of topics. The purpose, scope and procedure suggested for the preparation of the proposed manual was explained substantially, as follows:—

(a) **Purpose.**—To establish a code of good practice for the purpose of assisting Port Directors, Port Engineers and others responsible for the creation of port terminal facilities to adapt accepted and proven principles to new structures. It is believed that there should be an authoritative source where the best that has been thought and done by the most capable people in American port development, design and construction, could be set down in a publication sanctioned by the American Association of Port Authorities. This would, it is believed, go a long way toward the education of those who might be placed in high authority in port matters, without having a comprehensive knowledge of what is good accepted practice. Furthermore, it is believed that the integrated knowledge of many authorities should tend to establish a code of high standards which could be adapted to local conditions, which in turn would lead to the general betterment of American port facilities.

(b) **Scope.**—The manual would be developed first as a brief work covering the main points suggested in the outline attached to this report. It would be appended and revised after the manner of a "Year Book," until it reached a point where it could be published as a complete book. It is envisaged that this undertaking would take considerable time and would achieve perfection as result of continuous revision extending over several years.

(c) **Procedure.**—The comments and suggested changes to the original outline would be incorporated into the working outline which, in turn, would be broken down into chapters and topics. Dummy books covering the outlined topics would be distributed to each member of the committee. A nucleus of research material would be set down in the books with blank space for each member to write his criticism, elaborations, experiences and opinions. Supporting data and graphical illustrations would be requested for insertion. After a period the work copies would be called in and a composite copy listing the accumulated data would be prepared, after which it would again be sent to the committee members so that each might read and criticise the material set down by all the others. Finally, the book would be returned and the various chapters again would be sent to individual members for editing. Ultimately the plan would be to have each member responsible for a particular chapter, preface and sign the chapter which he organised and edited.

The response of the present committee members to the above plan of procedure was generally favourable. The helpful comments and criticisms which were made will be reflected in changes to the original outline.

So much material which should accompany the first circulation of the dummy manual has been received prior to the annual meeting, that the submission of it to the members will be delayed until some time after this meeting.

It is intended and hoped that by next year at this time a preliminary draft of the manual reproduced in pamphlet form, preferably by offset press method, can be passed to the members of the Association for comment and criticism.

The normal activities of the Association affecting port development and construction have been extensive during the year interval since the last annual meeting. The committee extends its appreciation to Mr. Amundsen for his excellent coverage of port development and construction work through the medium of his "World Ports," and, in this connection, special commendation is extended to him for his August, 1948, issue devoted to "Marine Terminal and Port Design."

Mr. A. H. Abel, in addition to his chairmanship duties in connection with Committee III and the panel on Public Port Preparedness for Emergency Use of Port Facilities, his participation in the many activities of the Association and his responsibilities as Manager and Chief Engineer of the Port of Oakland, has collected and furnished the principal data for the remainder of this report.

Mr. George Nicholson has contributed the engineering data, which surely offers the substance of the design for the future. Mr. Robert R. Shoemaker has likewise contributed greatly to the sum total of material through his frequent communications and the submission of data on his engineering works at Long Beach. Mr. R. K. Smith, President of the Association, through Mr. Abel, has

*Committee's report (slightly abridged) presented to the American Association of Port Authorities, at the 37th Annual Meeting and Convention, Montreal, Canada, September, 1948.

Port Development and Construction in the U.S.A.—continued

supplied a comprehensive report on port development, new construction and construction costs as they affect the ports of Canada.

There is much of importance and interest to the Association concerning new works and design which should be elaborated upon.

The Canadian ports, under the National Harbours Board of Canada, are engaged in extensive construction at Montreal, P.Q., Halifax, N.S., and Saint John, N.B. Of particular interest at Montreal, from the engineering design standpoint, is the use of 7-ft. O.D. by 70-ft. long pre-cast concrete cylinders with reinforced concrete deck. This construction affects the reconditioning of the upstream face of the Jacques Cartier Pier. At Halifax and Saint John, marginal construction involves the use of pre-cast sectional concrete cribs which are filled and backed with rock.

At the Port of Long Beach, a transit shed serving two berths —which achieves the ideal in the thinking of many engineers and operators—has been built during the present year. It features a 200-ft. clear span rigid frame structure with a 32-ft. vertical clearance at the centre. This structure is 1,152-ft. long and is supported on solid fill except for the apron portion. The characteristics of this facility, which result from long and careful study, offer a standard of perfection in themselves and are a tribute to the planners of Long Beach and the engineering ability of Mr. R. R. Shoemaker. During the year, Pier No. 2 in Long Beach was rebuilt following a fire which destroyed the former creosoted pile supported structure. The new pier employs a steel sheet pile bulkhead with the loads adjacent to the bulkhead being carried by a pile supported relieving structure, thus reducing the earth pressures on the bulkhead due to surcharge and live loads. The novel handling of this problem permitted the re-use of the underwater portion of the piles remaining from the former structure.

New construction at Los Angeles in excess of $5,500,000 is active at this time and the high standards of construction established for this port by Mr. E. C. Earle, Chief Engineer, are being carried forward. The solution of the combined passenger-general cargo facility problem which has been worked out before at Los Angeles is well established as a standard; however, we are compelled to call attention to the current construction of such a new combined facility at Berth 154.

New Orleans is engaged in current active construction amounting to $2,685,000. Of particular interest is Esplanade Avenue Wharf, which was started in June, 1948. The poor foundation soil conditions and extreme variations in water level, due to the seasonal stages of the Mississippi River, make wharf construction difficult in this port. The wooden foundation piles are capped with concrete at low river stage elevation. Superimposed on the foundation system is a secondary substructure of structural steel approximate 20-ft. above the primary foundations, a concrete floor is placed thereon. Non-combustible construction of the desired permanence is achieved. It is observed that the rear platforms of the 170-ft. width sheds is 30-ft. wide, providing a covered two-lane truck road.

The Port of Oakland is cited as an example of building to an admirably well conceived master plan, both as to area development and structural design. The new construction at Brooklyn Basin Channel is a progressive step in the fulfilment of this master plan, which was last modified in 1945 as a result of war-time construction. The basic plan conceived a decade before is substantially unchanged. San Francisco harbour development at Mission Rock is noteworthy from a construction standpoint in that the reinforced concrete cantilever type earth retaining wall at the rear of the concrete pile supported apron was pre-cast in sections at a point removed from the pier site using mass production technique. The completed sections were transported by barge to the pier site and were placed in position with floating derricks.

The $5,000,000 Hoosac Pier Project in Boston is more than one-third complete. The base structure employs a design similar to the reconstructed Pier 2 in Long Beach. The employment of a pile relieved apron surrounded by sheet steel bulkhead in a 10-ft. tide range proposes an interesting construction problem.

The Port of Mobile is engaged in the construction of the first element of a 12 million dollar system of marginal wharves. The change-over from finger pier type of construction, which was formerly constructed and which has stood as an example for over twenty years, is worthy of note.

The first phase of an extensive project, involving 16 millions of dollars in new construction, is getting under way at the Port of Sacramento. The wharves designed by Mr. George F. Nicholson are of solid fill construction employing a tremie-rock-mass concrete gravity wall of interesting and novel design. Rock is placed behind pre-cast concrete forms which form the face. Concrete is tremied into the placed rock. The structures, which are staged in 4-ft. lifts, take the form of a gravity wall. A mass concrete wall is poured on top of the rock-tremie section from M.L.W. to the apron deck elevation.

At the Port of San Diego an extensive development for the small vessels of the fishing fleet is in progress.

The matter of construction costs and engineering economics are of particular interest and concern at present. The rapid advance in the cost of structural materials and the more rapid rise in construction charges have already seriously affected many projects. Engineering estimates based on unit cost considerations repeatedly result in bid prices exceeding the engineering estimates. This is probably due to the lag between the time the estimate was made by the designing engineer and the contractor costs at the time bids are taken. In the current rising market the contractor adds a contingent margin which forecasts the anticipated operating expense which he expects will prevail at the completion of the work. As a result, costs are compounded and the structure which at the time funds are allocated is of high quality must be cheapened to stay within the original estimates.

The following tabulation, which compares similar current costs in various parts, ignores the type of construction and the many variables which make such a comparison of little real value. However, these figures gives some notion as to what port facility costs are running on Type "A" construction at random locations:

	Per lineal ft. Supported Structure	Per sq. ft. of Wharf or Pier	Per sq. ft Transit Shed
Boston	$950.00	$7.00	$5.00
Long Beach	667.00		6.40
New Orleans	575.00	9.34	3.42
Los Angeles	543.00		5.50
San Diego	500.00	8.00	
Montreal			4.75
Sacramento	500.00	8.00	4.50

It has been extremely difficult to secure accurate figures upon which to base cargo handling efficiency. The Army keeps accurate records in its facilities in the various ports where Army cargo is handled under contract. It is noted that in ports where the operation approaches 100% palletization, the output per gang hour is higher and the cargo handling costs are correspondingly lower. One example is the New Orleans Army Base, where palletization is approximately 90% and the average output per gang hour over a 6 months period has been 20.9 weight tons and 37.5 measurement tons.

Reports received indicate an increase in cargo movement between port terminals and hinterlands via motor truck transportation. This fact is reflected in the numerous current plans for motor truck circulation in port areas as well as for freeways to permit truck traffic to circumvent congested city traffic.

In conclusion, it must be stated that this report gives but a brief sketch of the activity of its committee members and the Ports of the American Association of Port Authorities. It is hoped that those desiring to learn more of the detail of the port development and construction as it affects a particular port, may find a suggestion herein which will lead them to good counsel.

P.L.A. Tide Tables.

The Port of London Authority have just published Tide Tables for 1949. The book gives the times of High and Low Water at Southend Pier, Tilbury Dock, Royal Albert Dock, and London Bridge. A Table of Constants enables one to ascertain times of High and Low Water at intermediate places between Teddington Lock and Hole Haven. The P.L.A. Tide Tables are available, price 3s. each post free, from the Information Office, P.L.A., E.C.3.

Tide Models

By Dr. A. T. DOODSON, F.R.S.,
Director of Liverpool Observatory and Tidal Institute*

The representation of tidal motion by means of small-scale models is of increasing importance, so that it is desirable for Hydrographic Services to understand the limits of usefulness of such models. Hitherto they have been developed by civil engineers who have tended to be more concerned with the engineering problems than with the effects on tides and who have approached the problems with an inadequate knowledge of tidal theory and problems.

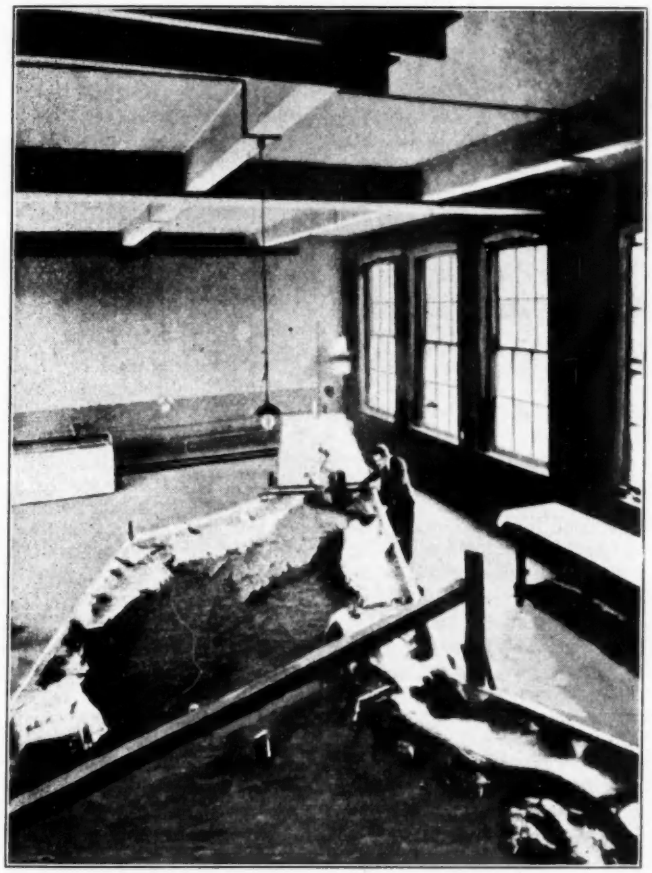


Fig. 1. General view of Severn Model.

Figure 1 gives an illustration of a model used to investigate a proposed barrage across the River Severn. The mechanism used to produce a motion of the water in the model, and which is presumed to be the correct generator of tidal motion in the estuary, is illustrated in figure 2. It consists of a plunger which is moved up and down in the water through variable ranges from springs to neaps. The plunger is shaped according to the shape of the tide curve at the seaward end of the model. Certain relations between the horizontal scale, the vertical scale, and the time scale, are derived from the equations of tidal motion, and thus in order to understand the underlying theory of models it is necessary to consider these equations. Though these may be unfamiliar to hydrographic officers, it is not necessary to understand all the symbols such as those for the differential operators, and sufficient will be said to make clear what the terms mean. The equations will be stated for a channel of uniform breadth but this limitation does not affect the deductions to be made from the equations.

*Lecture delivered during the Fifth International Hydrographic Conference, Monaco, April-May, 1947, and reproduced by kind permission.

We adopt the following notation :—

- x Distance along a channel ;
- t The time ;
- h The mean level of the surface above the bed of the channel, taken over a cross-section for all values of the time, at a distance x along the channel ;
- b The mean breadth of the cross-section at x ;
- ζ The mean elevation of the surface above the level h, taken at time t along the cross-section at x ;
- u The mean velocity in the cross-section at time t, measured in the direction of increasing x ;
- g The gravitational acceleration ;
- k A constant which has the value of about 0.002 when all variables are measured in centimetres and seconds ;
- Q The total flow of water per second across the section ;
- δ The length of a short portion of the channel ;
- u' The absolute value of u, that is, ignoring the sign.

The tidal equations are :—

$$\frac{\delta\zeta}{\delta t} + \frac{\delta}{\delta x}\left\{(h+\zeta)\,u\right\} = 0. \qquad \text{.....(1)}$$

$$\frac{\delta u}{\delta t} = -g\frac{\delta\zeta}{\delta x} - u\frac{\delta u}{\delta x} - \frac{ku'u}{h} \qquad \text{.....(2)}$$

(a) (b) (c) (d)

The first of these equations simply states that, within a small portion of the channel, the rate at which the elevation is increasing depends upon the rate at which water accumulates by horizontal

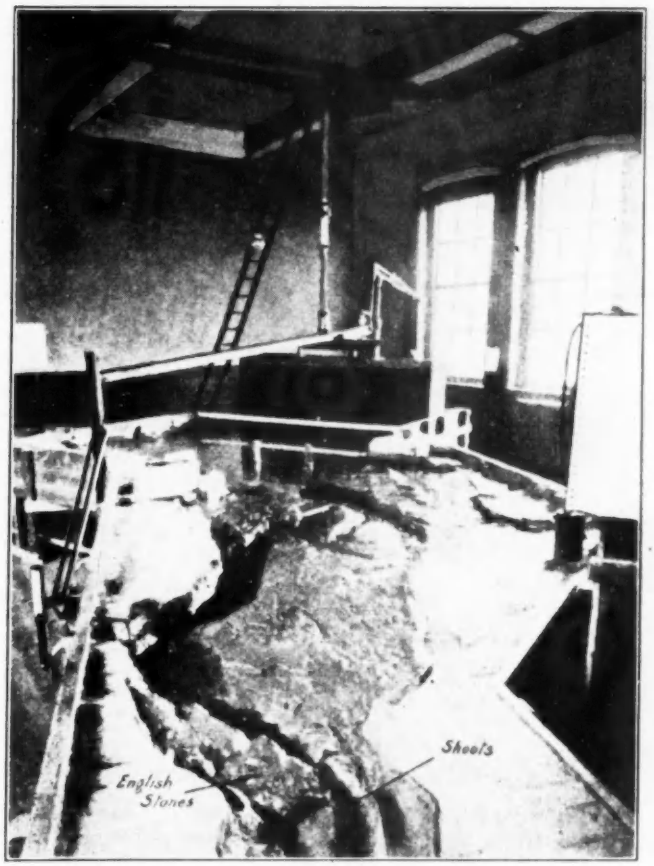


Fig. 2. Severn Model showing plunger.

flow. The second equation states that (a) the rate at which the velocity of the water is increasing depends upon (b) the loss of potential energy due to a fall of the surface, (c) the rate of change of the kinetic energy along the channel, and (d) the loss of energy due to the friction caused by the water moving over rough surfaces. In very deep water, where the velocity is small, the terms (c) and (d) can be ignored.

Tide Models—continued

If we wish to consider the motion on a different scale, we can apply the factors X, T, and Z to horizontal lengths, the time, and vertical lengths, respectively. Since the velocity is a change in distance per unit of time its appropriate factor is X/T. Since the model will operate under gravitational forces, g is unaltered.

In equation (1) the three terms have the factors

$$\frac{Z}{T} \quad \frac{Z}{X}\cdot\frac{X}{T} \quad \frac{Z}{X}\cdot\frac{X}{T}$$

and these are obviously all equal to Z/T. The separate terms of the equations have thus been multiplied by the same factor, and therefore the equation is valid for all scales.

In equation (2) the four terms have the factors

$$\text{(a)}\ \frac{X}{T^2} \qquad \text{(b)}\ \frac{Z}{X} \qquad \text{(c)}\ \frac{X}{T}\cdot\frac{X}{T}\cdot\frac{1}{X} \qquad \text{(d)}\ \frac{X}{T}\cdot\frac{X}{T}\cdot\frac{1}{Z} \qquad \text{.....(3)}$$

and these are equal to

$$\frac{X}{T^2} \qquad \frac{Z}{X} \qquad \frac{X}{T^2} \qquad \frac{X}{T^2}\cdot\frac{X}{Z} \qquad \text{.....(4)}$$

Since the equation is only valid if we have a constant factor for all terms then we must have, from the terms (a) to (c) the relation

$$ZT^2 = X^2 \qquad \text{.....(5)}$$

The fourth term demands the relation X = Z, and if this were feasible then the water model would satisfy the tidal equations exactly, but any model of a large estuary demands a small horizontal scale, and an equal scale for vertical lengths would render the tidal motion almost imperceptible. The practice has been to exaggerate the vertical scale and to ignore the effect that this has upon the frictional losses, so far as the satisfaction of the tidal equations section by section is concerned. The exaggeration varies according to the size of the estuary but for the Severn model it was such that the vertical scale was 42·5 times the horizontal scale. This means that the frictional term in the equation was reduced to the fraction 1/42·5 of its value in nature.

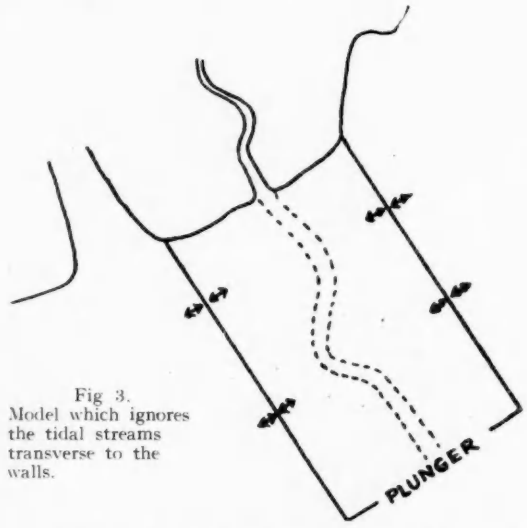


Fig 3.
Model which ignores the tidal streams transverse to the walls.

A very simple calculation from equation (2) shows that the frictional term is very important. It has been pointed out that in deep water the main terms are (a) and (b) and we can readily compare the first of these with the frictional term. If we are dealing with a semi-diurnal stream, then its increment of phase can be denoted by n radians per second, and this has the value of 1.4×10^{-4} for the principal lunar constituent. If the amplitude of stream is denoted by A then the amplitude of the first term (a) is nA, the amplitude of the frictional term is $0.002\ A^2/h$ and the ratio of the frictional term to the main term (a) is then 14 A/h. In the Bristol Channel west of Avonmouth the value of A is about 150, in cms per sec., and the value of h is about 2000, in cms. This means that the frictional term is just as important as any other term in the equation.

An investigation by Dr. S. F. Grace, of the University of Liverpool, on "Friction in the Tidal Currents of the Bristol Channel,"* gives ample confirmation of this conclusion. For a typical cross-section we can deduce from his results values for the terms of the equation for each of two phases, as follows :—

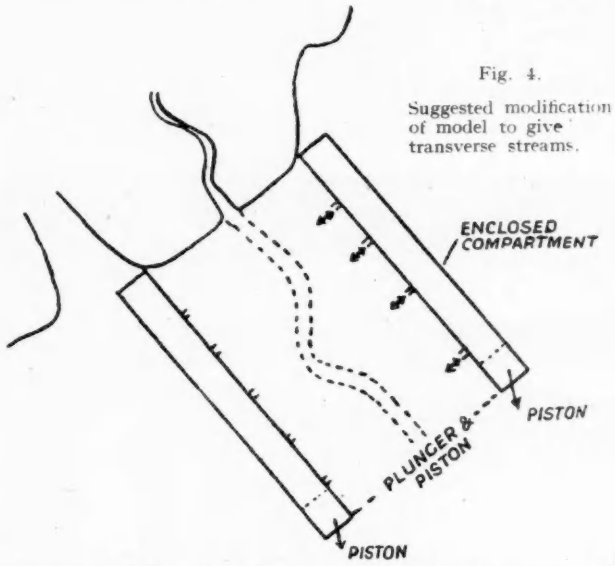


Fig. 4.
Suggested modification of model to give transverse streams.

Term	(a)	(b)	(c)	(d)
First phase	−0.019	0.000	.....	−0.019
Second phase	−0.003	−0.040	.....	0.037

It is therefore beyond all question that the neglect of the frictional term under such conditions is quite unjustifiable. The ratio 14A/h is a useful criterion of the importance of the term.

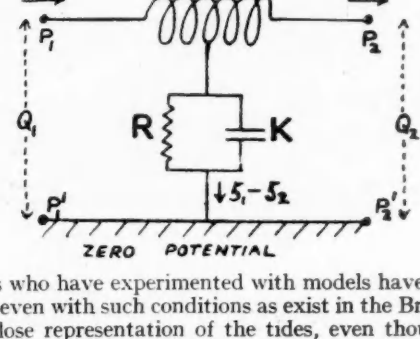


Fig. 5.
Electrical Unit.

Engineers who have experimented with models have claimed that the models, even with such conditions as exist in the Bristol Channel, do give a close representation of the tides, even though it is conceded that the tidal equations are not satisfied section by section. While this claim is not fully accepted by tidal experts there is some reason for thinking that the tidal model gives better results than might at first sight be expected from the above investigation. There is a need for more exhaustive examination of the factors involved, and more experiments are needed to determine precisely how and where the failure to account for the frictional term is to some extent counteracted. One possible explanation, in particular, needs consideration, and that is the effect of the exaggeration of vertical scale in producing losses of energy by shock ; that is, by the direct impact of water upon banks which in nature are gently sloping but which in the model are so steep as to be approaching the vertical. It is well known that tidal streams are reflected by steep banks. The result is a loss of energy, and it is possible that such energy losses may make up for the deficient energy loss due to friction. If the compensation of the deficient losses in a particular section were

*Monthly Notices, Roy. Ast. Soc., Vol 3, 1936, pp. 388-395.

Tide Models—continued

made up within that section then the compensation would be perfect, but what is most likely is that we get only an over-all result. For true similitude it is essential to have the losses of energy taking place in the right sections. If, for instance, the main losses of energy by shock occur above the point where a barrage is to be erected then the indications of the model after the erection of such a barrage will be misleading, as the losses of energy below the barrage will not be correctly given.

Another important consideration regarding tidal models is that engineers generally assume that a plunger will give a rise of level which will automatically take care of tidal streams. This is a very naive assumption. All tidal authorities recognise that it is vital to have the right relations of tide and stream, both in amplitude and in phase, if right results are to be obtained. Hydrographic officers ought to be on their guard and ascertain if any provision has been made for this condition to be satisfied. I am not aware (1937) of any model which has any but the most elementary representation of tides. This caution has most weight when the model has to do with an area of open water on either side of the deep-water approach to a river through sand-banks for a considerable distance. A model which erects walls on either side of the main channel and simply generates tides over a short portion of the end wall is simply ignoring the tidal streams which must exist throughout the whole area, transversely also to the side walls, in nature. See figure 3.

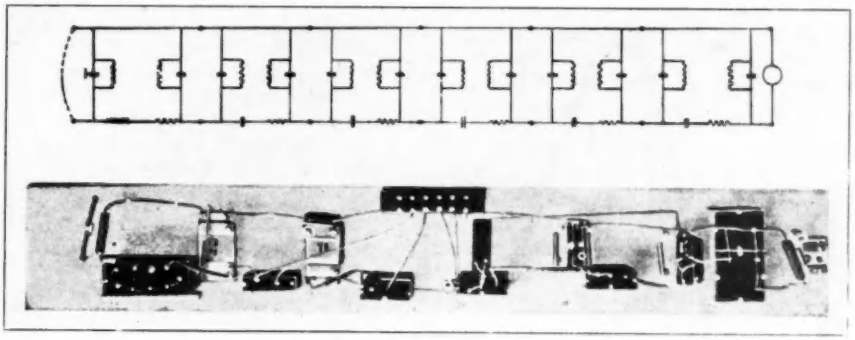


Fig. 6.
River Lek.

Obviously, in such a case as this it is vital that stream and tide observations should be made over the whole area before the model is commenced, for without these the indications of the model may be highly unreliable. The observations should be reduced by trained officers and not by the engineers. The mechanism for generating the water movement needs to be elaborated, and a vertical plunger should be supplemented by a horizontal piston so that the tidal streams will be correctly related to the elevation in both amplitude and phase. The bounding walls should be made double so that water can be forced in at the sides to ensure that the side streams are correct in amplitude and phase. They may have to be totally enclosed compartments from which water is forced by a piston geared to the main mechanism. The side walls can be pierced with holes whose sizes and positions will depend upon the observed rates of stream. See figure 4.

The question now arises as to whether the models can be modified, or if any technique can be adopted, by which the earlier mentioned difficulties may be evaded. Hitherto, far too many things have been attempted in one operation, for the model has been expected to deal simultaneously with the changes in the tides and in the bed of the channel. The proper course seems to be to proceed by a series of experiments.

The first essential is to make certain that the tidal equations are being satisfied. There should be the minimum distortion of scale, and artificial roughening should be resorted to in order to increase the friction. Banks which are nearly vertical should be smoothed off so as to reduce the un-natural shock losses. Every effort should be made to satisfy the equations for each section even if separate models have to be made for two halves of an estuary, one below a proposed barrage and one above. The effects of barrages or other alterations in the estuary may then be examined as regards their effects on tides and tidal streams, supposing that there is no change in the bed of the channel by silting or erosion. Laboratory experiments should be made to determine the limits of amplitude of tidal streams within which will be no resultant silting or erosion, and the effects of tidal streams outside these limits should be estimated. The bed should then be made deeper or shallower in the places where it is estimated that changes will take place and a fresh experiment be made to ascertain the new values of amplitudes of tidal streams. This process should be continued until a stable state is reached.

When the model has given satisfactory values for the tidal streams, the problem of erosion and silting should be examined by larger-scale models of specially important areas. Such models should have minimum distortion, and the streams on both sides should be regulated by means of plungers and pistons so as to give the streams correctly. In my judgment it is necessary to consider silt problems quite separately from the tidal problems.

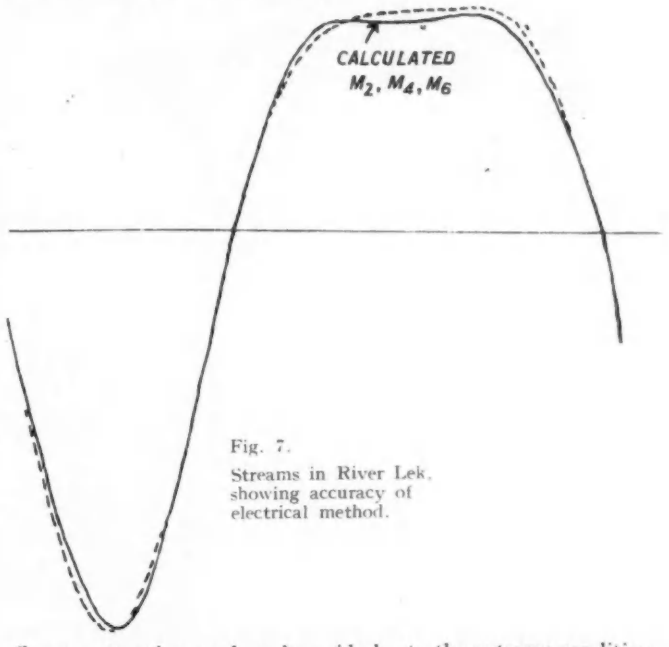


Fig. 7.
Streams in River Lek, showing accuracy of electrical method.

Greater attention needs to be paid also to the extreme conditions associated with meteorological disturbances. There is no doubt that changes in the bed of a channel are not simply due to the normal to-and-fro movements of the tide. Cyclical changes must have a cyclical origin and if the only cycle is that of the average springs to neaps cycle then no long-period changes can be expected. Exceptional conditions cause local changes and often start new cycles. This means that the model must be caused to operate with a right

Tide Models—continued

frequency of amplitude of tide, and not merely with average values. To sum up, I believe it to be essential to proceed by a series of carefully controlled experiments and not to expect a model to yield all the desired information in one operational process.

We now consider a totally different kind of model which gives an electrical representation of tides and streams in a channel. The apparatus was designed by Dr. Joh. Van Veen, Chief of the Research Bureau for Tidal Rivers, Rijkswaterstaat, Holland, and I am indebted to him for such details as are here given. Dr. Van Veen's own exposition is given in terms and notations familiar to the hydraulic engineer, but I shall attempt a fresh presentation of the principles in terms of the tidal equations already used, even at the risk of not doing full justice to the method. For our present

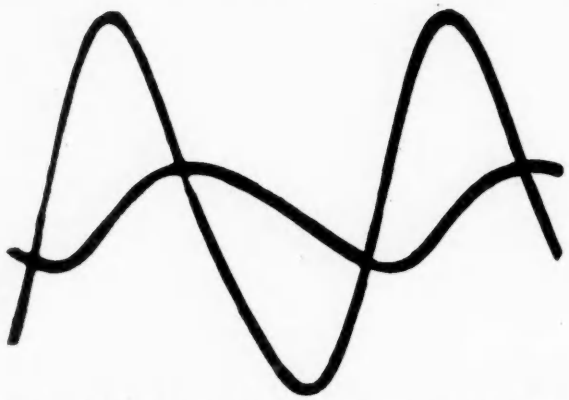


Fig. 8a. Vertical tide in the River Lek initiated by electricity.

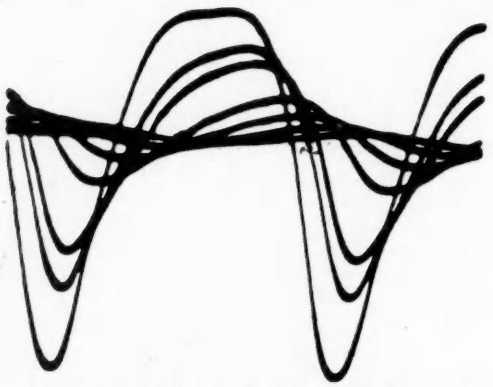


Fig. 8b. Streams in the River Lek initiated by electrical currents.

purposes the simplest exposition ensues if we assume that we can neglect terms of the equations which involve the product ζu and the square u^2, and if we assume that we can take the flow of water across a section as :—

$$Q = bhu$$

so neglecting one of the second-order terms mentioned. The equations become

$$-\frac{\delta Q}{\delta x} = b\frac{\delta \zeta}{\delta t} \qquad \text{.....(8)}$$

$$-bgh\frac{\delta \zeta}{\delta x} = \frac{\delta Q}{t} + \frac{ku^1 Q}{h} \qquad \text{.....(9)}$$

The variable δx denotes a short length of the channel, which we shall call d, so that we have

$$-\delta Q = b\,d\frac{\delta \zeta}{\delta t} \qquad \text{.....(10)}$$

$$-\delta \zeta = \frac{d}{bgh}\frac{\delta Q}{\delta t} + \frac{dku^1}{bgh^2}Q \qquad \text{.....(11)}$$

Let

$$L = bd \qquad \text{.....(12)}$$

$$K = d/bgh \qquad \text{.....(13)}$$

$$R = bgh^2/dku^1 \qquad \text{.....(14)}$$

and the equations become

$$-\delta Q = L\frac{\delta \zeta}{\delta t} \qquad \text{.....(15)}$$

$$-\delta \zeta = K\frac{\delta Q}{\delta t} + \frac{Q}{R} \qquad \text{.....(16)}$$

Now the forms of these equations suggest well-known electrical equations, the first for the relation between the potential $(-\delta Q)$ across an inductance L through which flows an electrical current (ζ), and the second for the current $(\delta \zeta)$ flowing through a resistance R in parallel with a condenser K, across which is a potential Q. The appropriate circuit is shown in figure 5. It is supposed that an electrical current flows along P_1 P_2 and some of it leaks to "earth," the line of zero resistance and of zero potential, P'_1 P'_2. Through the points P_1 P_2 there are currents ζ_1 and ζ_2 and the leak to earth is $\zeta_1 - \zeta_2 = -\delta\zeta$.

Fig. 9.

The mean current through the inductance is ζ, the mean of ζ_1 and ζ_2, and the potentials of the points P_1 and P_2 relative to earth are Q_1 and Q_2. This is one form of the circuit which satisfies the equations (15) and (16), so that if P_1 and P_2 correspond to points in the river, and if L, R and K are computed according to the values of the mean width, mean length, mean depth, and mean absolute velocity in the section, then we have satisfied the tidal equations (subject to the validity of the approximations made).

The whole river can be dealt with by stringing together a number of such units, and at the seaward end an alternator can be arranged to give an alternating current which expresses the tide at the mouth, while at the other end is a battery to express the steady flow of the river. A simple example is given in figure 6 for the river Lek. It will be noticed that Dr. Van Veen uses two sub-units of resistance and condenser on either side of the inductance, but the principle of action is the same as that outlined above. At any point P the introduction of an ammeter will give the mean amplitude of current, corresponding to the elevation of tide, and a voltmeter from P to earth will give a potential corresponding to the tidal flow, from which the mean amplitude of stream may be derived by dividing by bh. The accuracy of the results is illustrated in figure 7.

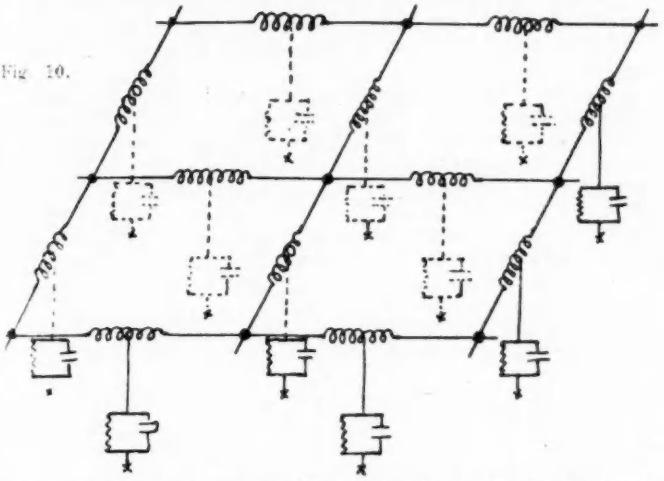
If it is desired to study the tide and stream moment by moment then an oscilloscope can be used, and two illustrations are given in figure 8.

The simplicity of the apparatus used is very striking, and it is quite evident that the tide and stream can be observed anywhere with great ease and speed. If an alteration in a channel is proposed the values of L, K and R can be readily changed also. The same methods of estimating the effects of silting or of erosion can be adopted as those already outlined above, but the ease with which the elements can be changed make the process very rapid.

Tide Models—continued

The method is capable of extension to all kinds of networks as shown in figure 9. It will be noticed that in this diagram Dr. Van Veen replaces the resistances by rectifying units which have the advantage of varying their resistance according to the current flowing through them. This is a big step forward as it is now no longer necessary to estimate u' which can be deleted from (14).

Fig. 10.



Network covering and area.—The inductances are in one plane and the resistances and condensers drop to points (X) on a lower plane which is at zero potential.

One very great advantage of this method is that the frictional term retains its full value. The terms which are neglected in the electrical method are adequately expressed in the water-model so that the two methods can be regarded as supplementary to one another. The terms neglected in the electrical method, however, are usually small, and they affect principally the quarter-diurnal tides. The method tends to give inaccuracies if (ζ/h) is not small. The term (c) in equation (2) is neglected, and the criterion is that u^2 must be small compared with $(g\zeta)$. Approximately, if the amplitude of stream is one knot, then the elevation must have an amplitude greater than one foot, for the neglected term to be more than 10 per cent. of the main terms. Dr. Van Veen believes that after the electrical model has given its indications and all adjustments have been made the final solution should be checked by the exact

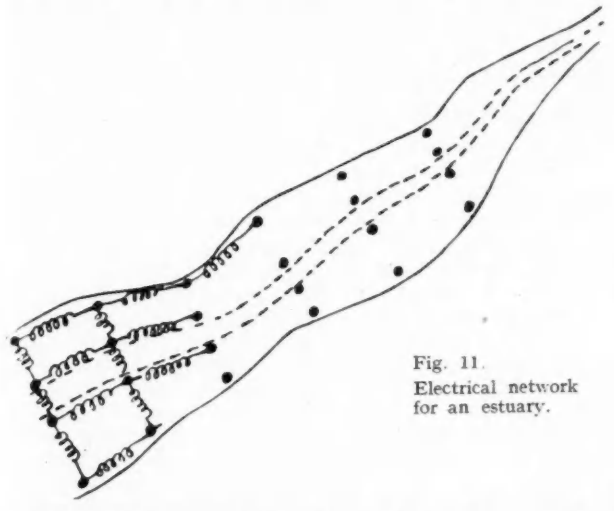


Fig. 11.
Electrical network for an estuary.

equations by direct calculation, with which opinion I strongly concur. I would suggest that the use of an electrical model as a check upon a water model and of calulation to check both, is the ideal combination.

It is not known whether the apparatus has been developed for use with a wide estuary, but the application can readily be made, as is seen from figure 10. A network of inductances in one plane is connected to earth in a lower plane by means of sub-units of resistance and condenser in parallel from the centre point of each inductance. The application to a converging estuary with a tidal channel of some depth in the middle, and shelving banks, is indicated in figure 11.

Explosions in Crankcases of Compression Ignition Engines

Ministry of Transport Notice to Marine Engine Builders, Shipowners and Shipbuilders

The high standards of design and construction of compression ignition engines in the U.K. have resulted in a correspondingly high standard of safety, and explosions in crankcases have been relatively rame, though when they do occur. they may be attended by more or less serious risk of injury; in one case recently there were a number of fatalities.

The Ministry have carefully examined the known facts of the explosions in the crankcases of compression ignition engines that have been recorded and have reached the conclusion that they have almost invariably been due to the overheating of an internal part and the consequent ignition of a particular mixture of lubricating oil mist and the atmospheric air present in every crankcase. The Ministry have come to the further conclusion that the risk of an explosion would be reduced if the following instructions were issued for the guidance of engineers in charge of this type of engine:—

(1) Early detection of over-heating and the prompt slowing down or stopping of the engine as circumstances permit will prevent the occurrence of conditions favourable to fire or explosion.

(2) Crankcase doors or inspection doors should not be opened and the engine should not be restarted until the engine has cooled down.

(3) Oil should not be sprayed on any surface the temperature of which is above blue heat (about 550° F.), as risk of fire is caused thereby.

Owners and masters will be in the best position to decide how these instructions should be brought to the notice of their engineers; one method already adopted is to arrange for them to be printed on cards kept permanently and prominently displayed in the engine room.

The Ministry have also examined the extent to which the risk of explosion in crankcases of compression ignition engines might be reduced by attention to the design and equipment of the engines, and the following recommendations are made for the benefit of those responsible for the design and construction of compression ignition engines of more than about 500 b.h.p.:—

(a) The attachment of the crankcase doors to the entablature should be substantial.

(b) There should be fitted in or adjacent to each crankcase door an explosion valve or disc of sufficient area to relieve any abnormal pressure within the crankcase and designed to reseat itself to prevent admission of further air.

(c) In multiple engine installations measures should be taken which, in the event of a crankcase explosion, will be adequate to prevent the passage of flame by way of oil drain or vapour pipes from one engine to another.

(d) Means for the detection of over-heating should be considered: it will be borne in mind that smoke from the oil in contact with the heated part is often the first indication of the existence of a hot spot.

Designers and builders of compression ignition engines should also consider whether, in order to obtain complete immunity from possible fire or explosion in the event of the development of a hot spot, it would be practicable to arrange for the installation of equipment enabling the injection of C O_2 gas to all parts of the crankcase.

The recommendations in paragraphs 4 and 5 of this Notice need not be applied to existing ships except where there is reason to believe that a definite risk exists.

Legal Aspects of Injuries at Work

Implications of Recent Legislation

By S. H. KESSELS.

To know something of the history of any subject is always to understand that subject better. So a review of the present law as to industrial injuries is the clearer for being pretaced by a short history. In fact that law has so built itself on the past that the effect of the recent radical changes (which have both clarified and complicated it) cannot be truly appreciated without a survey of the older law.

Under the present law (as from 5th July, 1948), a workman injured at work may claim weekly payment from the State under the National Insurance (Industrial Injuries) Act, 1946, and in certain circumstances he may also recover damages from his employer or some other person or body.

The legal picture before 1880 was very different. Of course, a workman then, like any other citizen, could always sue for damages a " stranger " or " third party " (someone or corporation other than his employer) if the negligence of the said third party (or " stranger "), or of his servant, had caused the injury—and also, in practice, if the injured person could find the money to support himself and carry on his legal action.

Apart from the remedy in those circumstances, there was no other resource but his meagre savings, if any, and then no other relief but to " go on the rates." Moreover, he may have lost his livelihood for the rest of his days, and remained a useless pauper dependent on such charity as he could get.

Since then, much legislation has limped or leaped through Parliament to redress that shabby state of affairs. The first enactment was the:

1. Employers' Liability Act, 1880

This entitled an injured workman to damages, not exceeding three years' wages, from his employer, if his injury was due to certain causes such as (a) breach of factory or other statutory regulations, (b) unsafe system of work, (c) faulty premises, plant or appliances, (d) faulty supervision or directions.

In those days it did not much help the workman. As Trades Unions were still weak, there was no legal aid for him, and one who sued his own master ran the risk of disfavour if not dismissal.

As the Act has been repealed as from the 5th July, 1948, nothing further need be said of it. The only tangible effect of the repeal is that claims for damages are not limited to a total of three years' wages.

2. Defence of Common Employment

This was not available as a defence to Actions under the Employers' Liability Act. This defence to any other action for damages has been recently abolished by the Law Reform (Personal Injuries) Act, 1948, as from the 5th July, 1948, but a few words must be given to the doctrine which had lasted so long. It was not set up by the common law or by statute, but by a series of legal decisions, the first of which was in 1837 (in the case of Priestly v. Fowler). Its effect was that a workman could not sue his employer for damages for injury caused by the negligence of a fellow servant, for he was deemed to have accepted the risk of his fellows' actions. The fellow servant had to be one, not in a supervisory grade, whose work brought him naturally into juxtaposition with the injured one, and who exactly was a " fellow servant " was often a matter of legal intricacy.

The doctrine became less and less reasonable as firms amalgamated and employing bodies grew larger, and the Courts always viewed it with disfavour even when they had to apply it.

3. What is Negligence? "

At this point some definition of negligence is necessary. It is a matter of broad interpretation from the facts of each case, and cannot easily be defined closely, but it may be summarised as a lack of that due diligence and care which a reasonable person should normally observe. There must exist a duty to take care, but such duty usually arises as between persons working or dealing with one another and those who may be in proximity. What exactly is negligence in every circumstance depends on the circumstance. Artisans and professional people are negligent if they do not exercise the usual standard of care and skill expected of them.

An employer is liable for the negligence of his employee committed in the course of his employment, but he is not liable for negligence committed by the employee outside the scope of the employment.

The circumstances of an accident may sometimes establish a " prima facie " case of negligence which may be hard to rebut. Thus, if a man working overhead drops a tool on someone passing beneath, it would not be a defence to say the tool just slipped from his hand.

The degree of care expected towards an invitee (one who directly or by inference is invited on to premises) is greater than that required towards a mere licensee (one merely suffered or allowed on premises). A workman is usually an invitee on any part of his employer's premises where he rightfully is, or where his work requires him to be. Stevedores, for example, are invitees on the ship they are loading or unloading, and persons going to a ship on business are invitees of the dock owners. A licensee must " take the premises as he finds them," but there is a duty to warn him of hidden or unusual dangers.

Dock and Harbour Authorities are usually compelled by their statutes to make and maintain their works and premises, but the general body of legal opinion is that this does not impose an absolute liability, only a duty to use reasonable skill and care in such maintenance. Failure to maintain in safe condition, as well as negligent maintenance, equally give rise to the same liability on the part of such statutory bodies.

Those who keep on their property things or creatures that would be dangerous if they escaped—like a large body of water or wild animals—have an absolute liability if those things or creatures escape (see the leading case of Rylands v. Fletcher, 1868), but if they keep them by statutory authority, as a dock authority retains water in a dock, they are not so liable unless they are negligent.

If injury arises from failure to observe the requirements of such Acts as the Factory Act, 1937, an absolute liability is imposed; and the only possible defence is that of negligence or contributory negligence on the part of the injured one (see Part 10 below).

Negligence may often occur in the legal sense without its being the gross negligence that merits disciplinary action—a genuine error of judgment may even be negligence legally.

The negligence or contributory negligence of the person injured may have considerable effect as a defence to his claim. Of this, and other defences such as inevitable accident, more will be said later in the part numbered 10.

Negligence, the basis of so many claims in legal disputes, is bound to be a wide and complicated subject, and the reader is referred to text books such as Charlesworth's " The Law of Negligence " or Beven's " On Negligence."

4. The Workmen's Compensation Acts

Now it is apparent that an accident, causing injury, slight or serious, can occur for a thousand reasons, apart from definite negligence or breach of duty. A slip of a tool, giving a slight cut that turns septic, a fall on stairs that causes an awkward sprain or fracture, all this sort of thing occurs daily. Until the first **Workmen's Compensation Act** was passed in **1887,** there was no provision for such accidents. Workmen's compensation has been elaborated and extended by many subsequent Acts (the principal one being that of 1925) and industrial diseases as well as accidents have also been included in its scope. After a long innings of 61 years it has been bowled out (on the 5th July, 1948), by the National Insurance (Industrial Injuries) Act of 1946, but as it still applies to injuries and industrial diseases sustained at work **before** 5th July, 1948, the main features will be set out and discussed here.

It was novel in principle, for it compelled employers to pay their workmen, if they were injured, weekly sums to " compensate " for the loss of earning capacity, and to pay their dependants lump sums in fatal cases. For the first time the workman received recompense, slight as it was, for injuries or diseases arising " out of and in the course of employment " quite irrespective of where the fault lay. The only exception to this wide application was that

Legal Aspects of Injuries at Work—continued

if it could be proved that the accident was due to the serious and wilful misconduct of the man, compensation was not payable, unless death or serious and permanent disablement ensued.

With this Act arose the general practice of employers to insure against their liability, with insurance companies. The latter came to have the same rights of prosecuting or defending claims in the name of the actual parties involved as those parties had.

The extent of the liability may be realised when it is said that in 1938 there were 445,000 compensation cases (arising from both accidents and industrial diseases).

The long and formidable list of industrial diseases which eventually came to be scheduled to the Acts included such as dermatitis, silicosis, nystagmus, lead poisoning, anthrax. Of these, dermatitis and anthrax are about the only ones that most concern dock workers, and the second of these diseases (incurred by handling hides, skins and the like) has become, by dint of careful precautions, of rare occurrence.

One has only to peruse the lengthy standard text book on Workman's Compensation to see that what should have been a simple measure to provide for those unfortunate enough to be injured at work (and the risk was increasing with increasing mechanisation) became cluttered up with legal decisions on a hundred and one details, and perhaps no single branch of statute law has caused so much litigation. Naturally the employer (or his insurance company) tended to pay as little as legally possible and the man to strive for all he could possibly get for his injury.

Interpretation of the meaning of " accident," alone, has been the concern of hundreds of legal decisions which fell as often one side of a hair-line as the other. To quote two cases—the blistering and subsequent sepsis of a miner's hands, on his resuming work after a long spell of unemployment, was held to be an accident within the meaning of the Act; the gradual exhaustion leading to the death of a stoker through his having to work several days in tropical heat was held **not** to be an accident. The Courts have also dealt with numberless cases on the point of whether the injury arose " out of and in the course of employment."

The basis of recompense was loss of earnings, being, in the case of total incapacity to work, a weekly payment equal to half the injured person's earnings and subject to an ultimate maximum of 30/- weekly, and in fatal cases a lump sum was payable for the benefit of dependants.

The lump sum, in fatal cases, was a maximum of £400 for a widow or adult full dependant, plus something in respect of dependent children under 15 according to their number and ages, so that the outside maximum for widow and children together was £700. These sums had to be paid into the County Court, the Registrar of which acted as a guardian and would pay out to the dependants at his discretion.

The weekly sum carried (since 1943) a supplementary payment of 10/- weekly, plus 10/- for a married man, plus 5/- for the first child—a total possible of 55/- weekly. (The supplementaries for the first 13 weeks of incapacity were lower, being 5/- and 5/- and 5/- respectively).

If a workman, having partially recovered, could only earn less than before the accident, the weekly rate was half the difference in earnings, plus proportionate supplementary allowances and subject to an overall maximum of two-thirds of the difference if there were no children or seven-eighths if there were, and not in any case to be more than the compensation payable for total incapacity.

If a workman remains so incapacitated that he is virtually unemployable, he is entitled, from the 5th July, 1948, to an " unemployability supplement " of £1 a week, and this is payable by the State. This is actually a provision of the new Industrial Injuries scheme that has been made to apply to those still drawing workmen's compensation.

The workmen (under the Workmen's Compensation Acts) had to report his accident at once and to claim within six months. These were reasonable safeguards to an employer, who had to exhibit notices telling the workmen what to do in case of injury; and in practice the Courts did not bar a workman's claim for failure to observe these requirements, unless the employer was grossly prejudiced by the delay in giving notice or making a claim.

Where the injury was caused by the negligence of a third party (not in the service of the same employer as the injured man was) the employer who had to pay the compensation could recover those payments, as an indemnity, from that third party.

The Workmen's Compensation Acts did not deprive a workman of any right to recover damages that he might otherwise have had, but he had to choose, to make his " election " of one or the other. The principle was that he could not have both. If he took compensation he could not recover damages, and vice versa; but if he sued for damages and failed, he could resort to Workmen's Compensation, provided he had given the usual notice of accident and, in effect, reserved his claim to compensation.

It seemed, from the observations in 1946 of the majority of the Law Lords (3 against 2) in **Young v. Bristol Aeroplane Co., Ltd.,** that a workman must have **known** of his alternate remedy before he could be said to have " elected " to take one or the other, as against his own employer.

One curious feature of the Workmen's Compensation Acts was that employer and workman could agree to a lump sum payment (based on the Government Annuity tables) to dispose finally of the workman's claim to weekly compensation. To have a lump sum such as he may never before have handled is alluring to a man who may overlook that he must live on it perhaps for life. It has been said that pressure was often brought to bear on workmen to accept inadequate sums, but it is hard to see exactly what that pressure could be in recent years. An ignorant workman **could** be exploited, but most workmen are in Trades Unions whose officials and advisers are far from ignorant. Moreover, the lump sum agreement, to be valid and binding had, and still has, to be scrutinised and recorded by the local County Court, whose duty was to safeguard the injured person. Anyone with experience of the County Courts must agree that they were scrupulous in examining all the facts and medical reports.

No, the true criticism is that the **principle** of buying out a workman's claim to weekly payments in dubious. He may use the sum unwisely; he may open a business, and if he is inexperienced, as he usually is, he may come to grief and have no further resource but to apply for outdoor relief.

There is another reason. The workman's knowledge that his disability may have a lump sum value can affect his subconscious mind and retard recovery. The effects of the shock of an injury—" traumatic nuerasthenia "—are well known to the medical and legal profession, not to speak of the injured ones themselves; and this nervous or mental aspect is especially pronounced after head injuries. Post-concussion symptoms may drag on for years, or they may vanish and the sufferer may be able to resume work, shortly after a lump sum settlement; yet it would not necessarily be true to conclude that conscious malingering is a factor in either event.

5. National Insurance (Industrial Injuries) Act, 1946

With the above Act the social pattern changed again. As and from 5th July, 1948 (as an item of the new social security measures) persons injured at work on or after that day are provided for by that Act instead of the Workmen's Compensation Act. The change is radical in several ways. The onus for providing for such persons is lifted from the employer (or his insurer) and placed upon the State, which, in short, insures all workers against the risk; but both employer and employee pay something for it—the employer 4d. a week as for each employee, and the latter 4d., the rates for women and young persons being slightly lower (3d. and 3d. for a women, 2½d. and and 2½d. for a boy under 18, 2d. and 2d. for a girl under 18 respectively). These payments are included in the much larger weekly sum, paid by a stamp put on a card, for all social security to which both the employer and employee contribute.

As the Act applies (with few exceptions) to **all** persons (whatever their work or incomes) injured by " accident arising out of and in the course of employment " (whatever the cause), it is of general interest and will be explained here at some length. An accident is assumed to arise " out of and in the course of employment " unless it can be proved otherwise—and this provision alone should put an end to the sort of dispute that so often arose about

Legal Aspects of Injuries at Work—continued

the precise meaning of those words in the Workmen's Compensation Acts.

All persons at work under a contract of service or apprenticeship are covered, except a few special classes such as police, naval, military and air force personnel, and some others, who are already provided for by their service regulations.

"Accidents" include those sustained while travelling to and from work in vehicles provided or arranged by the employer, and those which may occur in emergency, when a workman may do something outside the scope of his normal duty, to rescue or protect persons or property.

The ultimate fate of the compensation cases still current on the 5th July last has not yet been decided (please see part headed No. 4).

What are the new rates of benefit? Somewhat better than the previous compensation rates. Injured persons receive "injury allowance" during the first twenty-six weeks of disablement, and if the latter still continues after that time, they get "disablement benefit" (or "pension"), total or partial according to the degree of unfitness. Briefly, the injury benefit is 45/- a week for a single man or woman, 61/- for a married man or a person with an adult dependant, and 68/6 for a married man with one child or more (all but the first child are now entitled to Family Allowances in any case). Those under 18 normally receive roughly half rates. The maximum disablement benefit or pension is at the same rates, but, **in addition,** 20/- a week "unemployability supplement" is payable if the injured one is quite unable to earn by reason of the injury. (One is tempted to deplore the clumsiness of that word "unemployability").

(The workmen's compensation rate was, at the most, 55/- weekly for a married man with one child or more).

A vital difference is that, except for minor permanent disablement which may be compensated by a maximum gratuity of £150, there are no longer any lump sum payments either to dependants upon death due to industrial injury or disease, or by way of settling all further claims by a living injured person. By the new Act, a widow may get, instead, weekly payments varying from 20/- to 30/- plus 7/6 for the first child, and there is also certain provision for other dependants. A widow's pension of this sort ceases if she remarries, but then she receives a gratuity of one year's pension.

There are some further allowances which are dealt with below.

In assessing partial disablement, some regard is to be had to scars, disfigurements, or loss of parts which may not cause loss of earning power—again, a change from the previous law. The medical assessors apparently base the degree of partial disablement mainly on physical or mental impairment, rather than on loss of earning power. It was apparent, however, that this was too hard and fast a basis for actual assessment of the **benefit,** and could react harshly on the recipient. For example, the loss of an index finger, which may seem a definite impairment easily assessed, may but slightly impede a dock labourer, but could very likely mean the whole loss of livelihood to, say, a carpenter. The 20/- weekly unemployability supplement was accordingly provided.

But there is another and frequent type of case to which that supplement would not apply. A dock worker (let us say unmarried, for simplicity of illustration) might have earned £8 a week originally and now, because his impairment prevents his making the pace in a piece-work gang, might only earn £4. This man would have received 40/- weekly as workmen's compensation, but if his disablement is medically assessed at, say, 50%, the present disablement benefit would be only 22/6. Accordingly, Section 14 of the above-mentioned Act of 1946 (as to industrial injuries) was designed to remedy this anomaly, and to allow a man a further sum of up to £1 a week. A man cannot have both this supplement **and** unemployability supplement.

There is a further supplement ("constant attendance" supplement) of up to £1 weekly (or in extreme cases £2) payable **in addition** to unemployability supplement if an injured person needs constant attendance.

Thus it may be calculated that in the case of a family man rendered quite helpless by industrial accident or disease, a total weekly sum of £6 8s. 6d. plus ordinary family allowances might be payable by the State (68/6 benefit plus £1 unemployability supplement plus £2 constant attendance allowance).

While the Workmen's Compensation Acts ignored the constructive aspects of vocational training and aids to recuperation, the new Act empowers the Minister of National Insurance to attend to these. It may be a condition of getting unemployability supplement that the person drawing it should accept such training or recuperative aids that are made available to him.

The State has no present power of recovering an indemnity of benefit it may pay to a person injured by another's negligence.

The method of getting benefit is necessarily different from the older one, and the reader is referred to the Regulations of 1948, under the Act, as to determination of claims. An injured person must at once report the accident to his employer and make his claim, with a covering certificate, to the local National Insurance Officer who pays the benefit as it may apply. If the Insurance Officer decides for some reason against the claimant, the latter may appeal to the local Appeal Tribunal, made up equally of employers' and insured persons' representatives, with a chairman chosen by the Minister. From that Tribunal appeals may be made to the Industrial Injuries Commissioner and beyond him there can be no further appeal. The medical assessment of degrees of disablement is done by a Medical Board and, on appeal, by a Medical Appeal Tribunal whose decision again shall be final.

Reference or appeal to the ordinary Civil Courts is cut out almost entirely, and it remains to be seen if this procedure will be as fair or favourable to an accident victim as the Courts have been over compensation disputes. Under the old Compensation Acts a man could call his own medical evidence and carry his appeal to the House of Lords if need be; but, of course, this worked both ways —employers, with all their resources, could do the same, and the loss of time, and cost to both parties was formidable.

The new scheme for appeals will certainly be cheaper for all concerned (even legal representation is not allowed at the Boards and Tribunals) and its good working will depend on the character of the tribunals, and the spirit in which the injured workers resort to them.

6. Claims for Damages

Thus it is seen that beyond making a few returns, the employer has no longer to be concerned with weekly payments; but he has not got rid of his troubles and liabilities so easily as all that. The Law Reform (Personal Injuries) Act of 1948 has somewhat further darkened, for the employers, an outlook that had already become dim.

There has been a tendency in the last few years for injured workmen to claim damages whenever they could, as instead of a mere two or three pounds weekly, they might thereby recover substantial sums, comprising their loss of wages and something over (see part No. 8, headed "Measure of Damages"). These claims were usually based on simple negligence if against a third party, but where a third party has not been involved, they have often been made against the employers of the injured men on the grounds of one or other of the following:—

(a) unsafe plant or premises;
(b) breach of statutory duty;
(c) unsafe system of working;
(d) faulty supervision or instructions.

The statutory duties especially affecting docks are set out in the part numbered 7 and headed "Statutory Requirements Affecting Docks."

It is rare nowadays that any breach of Factory Act or Regulations is a deliberate flouting of provisions that were earnestly designed by the legislature to safeguard workers. Such a breach would incur prosecution, but in any case most employers co-operate with H.M. Factory Inspectors to meet their requirements, and any breach that may occur is usually a temporary omission or oversight of some burdened official.

There was a clause in the Law Reform (Personal Injuries) Act, 1948, as originally drafted that was designed to relieve employers of liability for damages for breach of statutory duty if it could be

Legal Aspects of Injuries at Work—continued

shown that it was not reasonably practicable to avoid or prevent the breach, but this clause was dropped from the Bill during its passage through Parliament.

The tendency to claim damages has grown stronger year by year. Employers have found themselves called on to prove the safety of systems of work that have endured unquestioned for decades. There is a high degree of duty on the part of employers to provide safe premises and a safe system of working, and dock owners have had to pay a number of claims for damages for injuries caused by defects in their quays and sheds due to the wear and tear of war traffic, although in practice it has not been possible to put the premises in an ideal state of repair all at once.

Some of the claims have been essayed on flimsy grounds, and occasionally the sums claimed have been so exaggerated that the claimants might almost have been inspired by reading in the newspapers of the astronomical figures that are sometimes claimed in American lawsuits.

Even if the employer is successful in defending an action, he often finds that his legal costs are a dead loss. With the Law Reform (Personal Injuries) Act, 1948, the number of claims has increased still more.

(To be continued)

Book Reviews

Structural Foundations, by R. R. Minikin, 360 pp. and 210 illustrations. Published by Crosby, Lockwood & Son, Ltd., London. Price 25/- net.

This useful book is primarily concerned with the more recent practice of foundations engineering. In an endeavour to satisfy the needs of students, designers, architects, engineers, and all concerned in structural foundations, Mr. Minikin has set forth in simple terms the fundamental rules of good engineering practice to ensure stable foundations. A long experience of a great variety of constructions has given him the opportunity to note the differences, economic and structural, of design and method and it is from the knowledge so acquired that he has been guided in the compilation of this book.

The author has treated the subject from the practical angle for the designer, or builder, of large or small foundations. The problems of more technical difficulty have been simplified wherever possible. The relevant practical details are interlarded judiciously with theoretical considerations to lend interest and to emphasise usefully, the value and admissibility of the assumptions upon which a theory is based. The Soil Mechanics section is confined to the practical application of the main principles. The subject matter covers the whole range of operations for the recognition of ground, its value for load-bearing purposes, and the more recent methods of design and construction to ensure stable foundations.

The book is well produced, and altogether is a valuable addition to the literature concerned with structural engineering.

Tomorrow's Continent, by Peter Penn and Lucie Street, 180 pp., with 3 maps by J. F. Horrabin. Published by Sidgwick & Jackson, Ltd., London. Price 9s. net.

In this book, Lt.-Col. Peter Penn calls upon his 30 years' experience in East, West and Central Africa to expound some drastic and revolutionary proposals concerning the future of those Colonies. He and his wife, Lucie Street, maintain that all Colonial development schemes in the Continent should ultimately result in the creation of a United States of Africa.

They visualise a Cape-to-Cairo route as one vast transport system comprising air, road, rail and water, all linked together and radiating out to ports and harbours for inter-coastal trade. Canada has its trans-continental railway, the Canadian Pacific, connecting east coast to west, and India has its trans-continental railways, but Africa has no through connection from Cape to Cairo either by road or rail. Only in certain seasons of the year can the journey be attempted at all, using rail part way, light lorry or car most of the way, risking life in floods or loss of the machine in dust as deep as Sahara sand. There is not even this hazardous mode of transport between our East and West African Colonies, between the Ports of Mombasa and Lagos.

The authors also visualise the enormous inland lakes of Africa as busy waterways, linked by great canals, carrying craft of all sizes, from train ferries to native paddle-boats. Canada uses her great lakes as arteries of traffic; Africa can do the same.

There will be considerable divergence of opinion with the author's contention that "British Africa with its thousands of miles of coastline, has only two ports, whose tonnage might compare with that of Grimsby. They are Capetown and Durban. Of the remaining ports in Africa, not one could compare in tonnage even with Grimsby. On the eastern coastline, between Alexandria and Capetown, the most sizable port is Port Sudan, on the Red Sea, which serves part of the Anglo-Egyptian Sudan. Coming south along the shores of the Indian Ocean, Mombasa, which serves Kenya, could admit five small ships of 8,000 or 10,000 tons to berth alongside. But a ship of 8,000 tons at Dar-es-Salaam could enter the harbour only at nigh water, and would have to be unloaded by lighters, as she would not be able to come alongside. Now at last work to enlarge it has begun."

The comparison between Grimsby and Cape Town or Durban is unfortunate, as it gives a totally wrong perspective. Grimsby is essentially a fishing port, and apart from the handling of fish and coal for bunkers its general trade is comparatively small. Also, the authors make no mention of Port Elizabeth, East London or Beira, and all these ports handle large quantities of cargo destined for the Rhodesias and other African Colonies.

Finally, the authors ask how can a territory be developed when every import is limited to what can be handled by Africans in small boats? They suggest that British apathy on the subject of ports has acted like a strangle-hold on the life corporate of the Colonies, and one important task in front of us is to enlarge the ports in British Africa. "It is a prime task, for till it is done we can do nothing in the interior on a large scale, and the cost of what we do on a small scale will be quadrupled by the handling necessary at these small ports."

"Prestressed Concrete," by Professor G. Magnel, 224 pages, 164 illustrations, 1948. Published by Concrete Publications, Ltd., London. Price 15s. net.

In this book Professor Magnel, an eminent reinforced concrete engineer with English as well as Continental experience, describes the principles and practice of this new method of building in a way that will enable those who study his book to design and erect prestressed concrete structures. A notable feature of the work is the simplicity of the design methods, which allow for the various losses of prestress. The principles described are in nearly all cases corroborated by tests made by the writer and by the behaviour of structures he has designed. The method of prestressing described in detail is that used in some of the most important prestressed concrete structures yet built and which the author has supervised, and accounts are also given of the methods adopted by others. The semi-graphical method of calculation given is applicable to the design of beams prestressed by any method. The work describes the design of simply-supported beams and slabs, with numerical examples from practice; the design of continuous beams, tests on prestressed beams of various kinds, including a continuous beam; tests to determine the amount of creep in concrete and steel and to establish the fact of the high resistance to buckling of prestressed members; the reduction in the prestressing force consequent upon shrinking of the concrete and creep, the reduction due to stretching the wires in pairs, to the slipping of the wires in fixing devices, and to other causes, and co-efficients are given for use in practical calculations. Suitable working stresses are recommended. The final two chapters describe bridges, buildings, silos, and other structures designed and erected in prestressed concrete under the supervision of the author, and pre-cast prestressed products. Dimensions, weights, stresses, and the like are given in English units, generally with the metric equivalents. The notation is similar to that commonly used in Britain for ordinary reinforced concrete with such additional symbols as are required for prestressed concrete.

Coast Protection

A Survey of Beach Stability

By R. R. MINIKIN.

(Continued from page 198)

The problems of beach depletion or coastal erosion are not always associated with violent seas or exposed coasts. The phenomena is frequently present in sheltered bays, the lee of protection works themselves, and in harbours. An interesting example is Dover Harbour. The shingle beach which lies directly in front of the town (shown dotted in Fig. 26), one would imagine to be immune from any influence to migrate. However, the fact is that it has been found necessary to construct groynes G in the position shown N.E. of the open viaduct O. The harbour covers a large area and has a peculiar tidal current system. It is bounded on the west by the Admiralty pier and to the N.E. by the East Pier with an island mole running approximately N.E. to S.W. between the heads of the West and East Piers. The two entrances so formed allow the tidal current to circulate within the harbour as shown by the arrows. The full arrows show the direction three hours after High Water and the broken arrows three hours before High Water. It will be noted that the current circulates clockwise dragging the beach towards the east. The open viaduct O does not interfere to any extent with this phenomena. The large area of the harbour also promotes an inconvenient jobble productive of waves some 3-ft. high generated within the confines of the breakwaters. Thus the internal agitation so set up together with the tidal forces, apart from any ranging due to bad weather outside, produces similar erosive, or depleting forces, as occur outside.

Fig. 26. Dover Harbour.

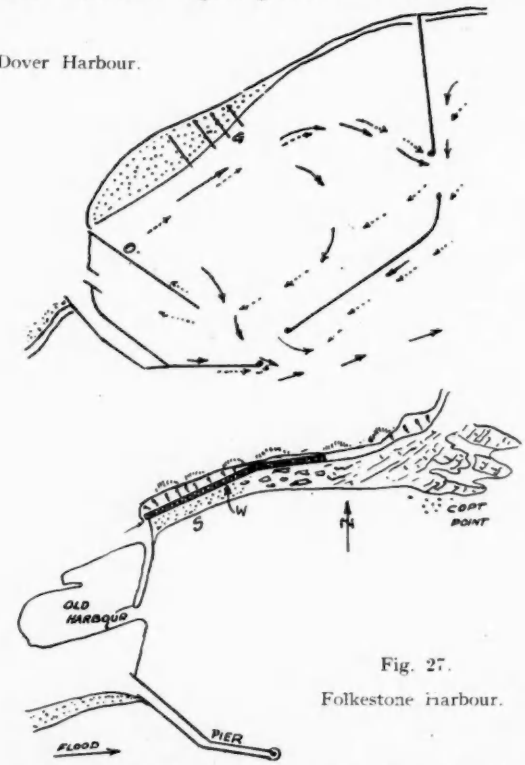


Fig. 27. Folkestone harbour.

The groynes are built up of a double row of old bulb rails driven a considerable depth into the beach. Between each line of rails there is a 3-in. space into which the 3-in. thick planking of the groyne is placed and bolted. The groynes are about 100-ft. apart and 100 to 120-ft. long.

Within six miles of Dover there is another harbour, Folkestone, in which protection works were required although the conditions are widely different. Folkestone breakwater is 1,600-ft. long (Fig. 27), and runs S.E. from the root. It will be noted from the plan that the line of the pier is oblique to the shore and the flood stream direction. Compare Bray Pier (Fig. 19). Both piers are similar in plan, but Folkestone pier is much longer: Bray pier is in the lee of Bray Head and presents a more obstructive front to the direction of the flood stream rounding the Head, deflecting it

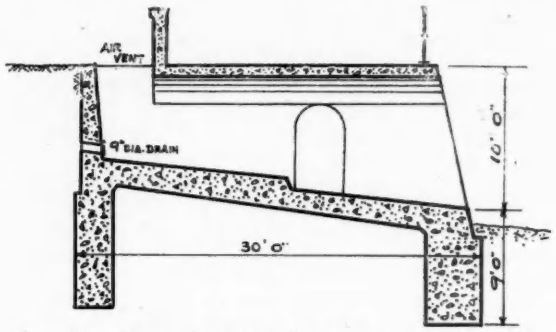


Fig. 28. Cross-section of Folkestone Harbour sea wall.

partially shorewards, whereas at Folkestone the pier is directly in the path of the littoral current along the coast, without any sheltering headland. The flood stream, at Folkestone, is therefore deflected gently seawards thereby promoting a considerable accretion of shingle in the less active waters in the angle of the shore and pier root on the south side. There is a stable shingle beach to the west of the pier for some 800 yards whereas the harbour beach is entirely sand. The littoral drift along the coast is mainly shingle. It is therefore highly probable that the deflecting action of the breakwater causes the mobile shingle to be pushed along over the sea bed across the harbour mouth to the N.E. beyond Copt Point to join the main stream towards Dover. The waters of the harbour being somewhat shallow, and less agitated, encourage the settlement of the suspended grains of sand.

From the short stone pier at the old harbour to Copt Point and beyond, high gault clay cliffs with soft rock lenses form the coast line. Not only are these cliffs vulnerable to weathering, and naturally subject to slips, but, without protection at the toe from the wash of the sea, are rapidly eroded. For this reason the problem at Folkestone was two-fold: to provide a sturdy wall to preserve the toe strength of the cliffs and to prevent erosion by the sea. A novel design of wall resulted (Figs. 28, 29 and 30). It is constructed in reinforced concrete and is substantially proportioned as the cross section shows. The strength is well illustrated by the fractured bay in the centre of Fig. 29. A washed-up sea mine detonated on the beach at the mouth of the arched compartment. The result was to fracture the deck, causing a hump of about 12-in., and spalling the corners of the side walls. The deck forms an excellent promenade and the arched form provides shelter for holiday makers who make good use of it. The arches are at 12-ft. centres leaving 10-ft. clear between walls. The beach is now for the greater part level with the bottom step. The engineer wisely provided a good air vent at the rear to avoid pocketing of air during heavy weather. The drains in the back wall were provided with heavy cast steel flap valves on the sea side, and a steel mesh to the land side, to hold the rubble back-fill. In many cases, particularly at the Copt Point end, the flap valves are broken, or the hinges wrenched from the frame seat. One extraordinary point is that, in several instances, the steel mesh guards are also broken. In this connection it is worthy of remark that large diameter drains, whether protected by flap valves or not, at a level exposed to breakers or heavy surge, even temporarily during rise and fall of tide, are always tended by trouble. Where drains are necessary it would be better to have a number of small diameter, inclined slightly upwards to the discharge. The upward slope tends to choke, but no more than the back-fill itself. It is very difficult to understand why some designers insert large diameter drains for back-fill drainage, particularly with submerged outlets. There have been instances of water spouting up to 5 to 6-ft. in the air from promenade roadway gullies with direct outlet on sea wall, which were submerged at high tide. A serious case of this nature

Coast Protection—continued

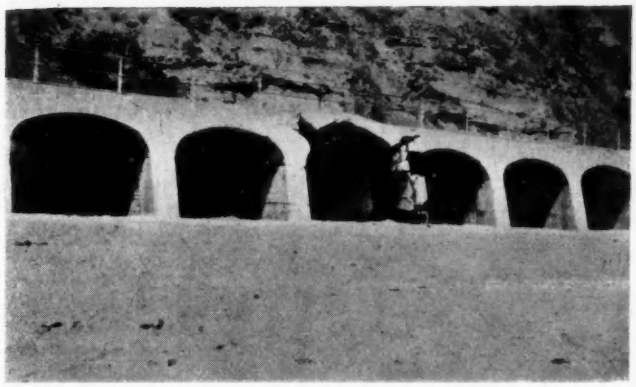


Fig. 29. Folkestone Harbour sea wall shewing damage by mine.

occurred at Alexandria where the shock pressure burst up the roadway and resulted in heavy damage to the sea wall. Flap valves are a very doubtful safeguard, for should they fail to act, a very frequent occurrence, there will be a flush and a draw-down at every wave stroke in the material behind the wall. This will rob the back-fill of all the fine material behind the wall and thus increase the void space. That this happened at Bray is indisputable (Fig. 20); a large part of the pavement collapsed in a deep pit behind the wall: the shingle back-fill, upon which the concrete pavement slab was originally cast, scoured out as much as 6-ft. deep.

Should the engineer decide that the hydrostatic head upon the back of a wall must be relieved, then the better plan for positive action and safety, is to collect the ground water in French drains and lead it to some outlet in a sheltered part discharging below half-tide level, or above high water level as the conditions require.

The problem of coast protection where steep and high slopes of clay abut at, or near, the high water line is nearly always productive of foundation difficulties. The earth pressure behind the wall, the hazard of earth slips, and the saturated condition of the sub-foundation, subject to the constant wash of the sea, call for substantial treatment. The rise and fall of the tides over the beach, which may be the toe of the slope, encourages the occurrence of slips by causing fluctuations of load. These arise not only from the hydraulic effects of buoyancy and the variations of the depth of water, but by the depletion of the beach material during heavy weather. The broken clay lumps spewing up on the foreshore from previous slips are soon disintegrated and carried away.

For these reasons protection works must be adequate to withstand high pressures from the landward side without overturning, or sliding, and they must be well anchored into a stable subfoundation. They must also be located outside of the critical circle of rotational shear at the time of construction, or made sufficiently heavy to counter-balance the rotational moments.

A form that has been proved useful in gault clay is shown in Fig. 31. A counterforted concrete wall of sturdy proportions protected at the toe with sheet piling is combined with a system of groynes matching occasional counterfort walls. The more material it is possible to accrete between the groynes the more stable the hinter slope of clay will become.

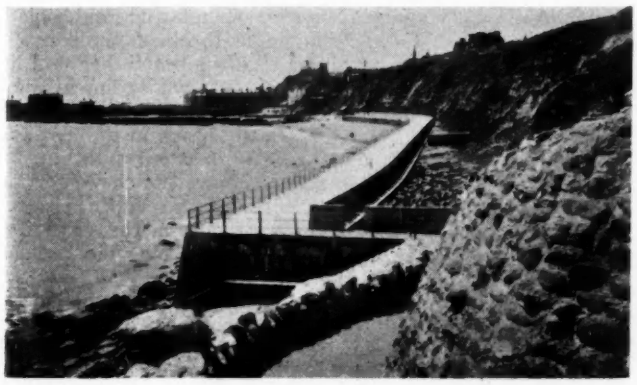


Fig. 30. Folkestone sea wall.

On the South Coast of England there is a continual struggle being waged with the ravages of the sea arising not only from storm action but from the cycle of change consequent on the local variations of the rate of travel of the littoral drift. One particular section of about 5 miles which has been expensive to maintain over this last century is Rye Bay from the Fairlight Cliffs, east of Hastings, to the outlet of the River Rother. A large area of some 60 square miles of valuable land, about Winchelsea and Rye, is below high water of ordinary tides. This area is therefore protected by banks along the coast and fringing the rivers of the district. There is a steady littoral drift of shingle from west to east which tends to form a spit fronting the River Rother outlet. To prevent the blocking of this channel a long groyne was built west of the harbour entrance. This trapped shingle for some time. The shingle bank then maturing deflected the surplus shingle seaward where it again caused trouble to navigation, necessitating a further seaward extension of the groyne, and a river training scheme to minimize the necessity for dredging.

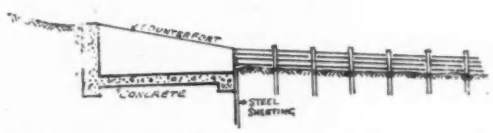


Fig 31. Protection Wall and Groyne at toe of clay slope.

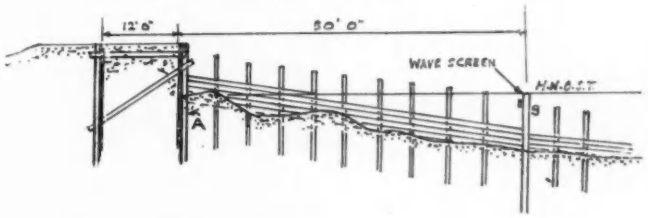


Fig. 32. Timber sea wall, groynes, and wave breaker.

It will be gathered that there was no lack of material travelling along the coast, nevertheless, the shingle beaches to the west of the harbour were being depleted in spite of the existing groynes. Eventually in 1930 a breach was made in the protection banks at Dogs Hill, west of Rye. The damage was not serious, but hazardous to the safety of the rest of the wall and countryside. It was in the circumstances decided to put in hand an extensive scheme of sea defence works, which, in sum total, amounted to almost £250,000, which represented nearly £25 per foot run of wall constructed. The foreshore is comparatively shallow. The shingle beach merges into a flat sand lower beach just below half-tide line. A very able engineer, Mr. Ernest Latham, was consultant to the Authority, and he advised a complete scheme of protection constructed entirely of timber for sea wall, groynes and wave screen. In passing it is worth noting that timber withstands the assault of wave projected shingle better than reinforced concrete.

To form the sea wall two parallel walls of 9-in. x 3-in. planking, 12-ft. apart, were supported on timber piles (A) at about 6-ft. centres (Figs. 32 and 33), the compartment was then filled with beach shingle. The top of this fill was 7-ft. above H.W.O.S.T. The line of the wall followed the high water line and was generally placed a few feet landward, part of the old embankment wall being incorporated in the new. The cross-bracing, planking, and pile connections are shown in Fig. 34. It will be noted that the ends of diagonal bracings (C) are carried well beyond the connecting bolt, to prevent splitting, and timber checked cleats (B) are used to hold them. Nowadays it is more economical and workman-like to use toothed timber connectors of steel of the " Bulldog " or " Teco " types. Fifty feet to the seaward and parallel with the wall a closely-spaced line of 9-in. x 9-in. piles (S) are driven into the beach

Coast Protection—continued

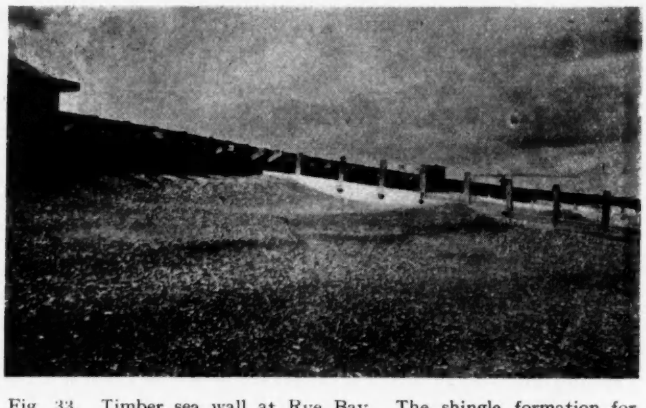


Fig. 33. Timber sea wall at Rye Bay. The shingle formation for two high beach crests is seen against the short inside groyne.

with the heads at high water level, that is about 7-ft. below the top of the wall. A 12-in. x 6-in. waling connects the heads (Figs. 35 and 36). These piles are at 18-in. centres. Here and there, to give access to the beach, the line is broken and over-lapped, one deviating at 11 o'clock and the other at 5 o'clock, leaving a parallel inclined gap about 8-ft. wide. Between this formidable row of timber and the sea wall at about 200-ft. spacing, timber groynes of 9-in. x 3-in. planking are connected to piles driven at 5-ft. centres (Fig. 37). The strakes of planking extend above high water. To the seaward of the wave screen, low groynes about 400-ft. apart, run for about 200 to 300-ft. over the sandy beach.

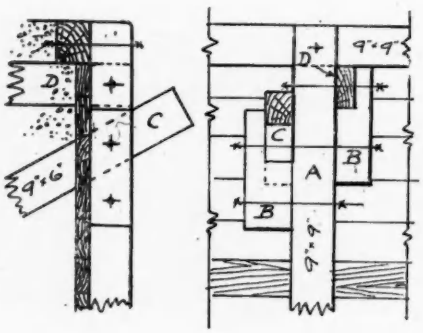


Fig. 34. Timber connections.

Fig. 35. The Foreshore at Rye Bay at low tide shewing the timber wave breaker, or screen, and the groyne system of the lower beach. Note the mound of shingle behind groyne just within wave breaker.

The tidal phenomena of this area is peculiar, insomuch that it is in the part of the channel, from Rye Bay to Dieppe, where there is a slackening of the flood stream. For several hours daily there is a weak tidal current along the coast. The ebb from the east of Dungeness and the flood from the west of Hastings combine hereabouts to form a resultant flow direction across the channel from north to south. The flood is much stronger than the ebb. (It is in this area that the tidal systems of the North Sea and Atlantic seem to have their boundaries). Compared to the adjacent sections of the coast the velocity of the current along the shore is relatively less. Hence under tidal conditions alone, the tendency is to encourage deposition. The flat sand lower foreshore is evidence of this condition, which is favourable for beach building, but unfavourable for harbour channel maintenance.

The prominences of the shingle beach shown in Figs. 33 and 35 show the crests built up by successive tides of lesser range, and plainly indicate the tendency to accretion in the weather corner only, between the sea-wall and short-groyne. Since completion almost fifteen years ago there is little change in the beach regimen and the material of the structure is in good order. Just inside the wave-breaker and to the right of the groyne lee (Fig. 35), it will be noted that there is a heap of shingle higher than on the weather side. The seaward side of the wave screen at the same position is shown in the fore-front of Fig. 38. This shows a groyne extension of about 25-ft. seaward and also the limit or verge of the shingle and sand beaches. The creep of the shingle around the extremity of the short groynes is shown in Fig. 36, as is also the heaping up in the corner between wave screen and the short groyne. This shingle builds up and tumbles over the groyne to the lee, and for a time, causes the temporary local accretion of Fig. 35. This action is plainly seen at all the short groynes. Where the long groynes of 200 to 300-ft. occur the conditions are different. In the lee of the long groyne seen in the distance of Fig. 38 there is very little shingle accretion, it is all spread out over the beach as shown in Fig. 39 and in the same bay, between the sea wall and the wave screen, there is evidence of the swirl of the currents and eddies (Fig. 37) set up by the long groynes. The long groyne is too high at the wave screen and cuts off the supply which would otherwise over-top or by-pass it, as in the case of the short groynes. The action most obvious to the eye is the thin wide spread out of the shingle between the long groynes, in those parts which are without the short groynes. Where there are short groynes there is a definite line of demarcation between the shingle and sand, pointing to the effectiveness of these constructions to hinder the eddy flow or lateral swirl. At one or two points of the beach there are rows of old timber piles close spaced (Fig. 40), whose line is almost perpendicular to the sea wall. Inspection of the photograph will show that there is no visible effect to the beach in the locality of these obstructions. Although the gaps between piles are only about 2-in. they neither hold shingle, nor yet do they show that they have any influence whatever on the beach regimen, excepting for some local scour near the cluster of piles at the seaward extremities. Note the spread-out of the shingle over the sand near the long groyne in the background.

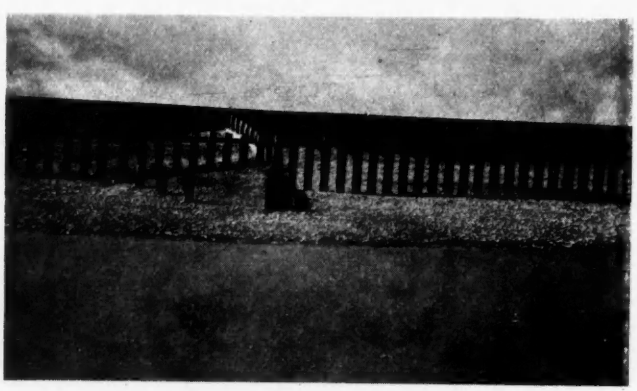


Fig. 36. The upper shingle beach at Rye Bay shewing stub groyne, wave breaker, and wall.

The approximate contours of the shingle in one of the bays between the wave screen and sea wall are shown in Fig. 41. At Groyne A the shingle is heaped up to the seaward of wave screen to relative height 4 overtopping the groyne so that on the lee there is a spill which causes the heap 4 and 3 to accumulate and thereby generally heightens the beach in the lee of the groyne. At B

Coast Protection—continued

where there is no spill over the top, the relative levels of the contours to the lee are less than at A.

The system of coast protection outlined above was developed by Mr. Latham from experience gained in the Severn Estuary where a substantial sea wall (Fig. 42) was theatened by undermining due to the depletion of a shingle beach. The remedial measures took the form of two rows of close-driven piling at 2 diameters centres of piles leaving gaps of 9-in. between them. The rows of piles were placed 30-ft. apart parallel to the sea wall and about 30-ft. from it. It was found, however, that there was no improvement of deposition until short transverse groynes were placed across the run of piles. These prevented the travel of the shingle along the beach. One should note that the tidal conditions of the Severn and Rye Bay are widely different, not only is there a much greater range, but the velocity of the tidal current is much higher in the Severn, and is more concentrated in direction, Note, too, that the heights of piles relative to high water level in the Severn are much less than the heights of the wave breakers at Rye Bay. It is to be noted that subsequent to the erection of the sea wall the beach accreted to the comparatively high level shown by the dash line. Some later influence depleted the beach to danger level, which was more or less the state when the wall was first contemplated.

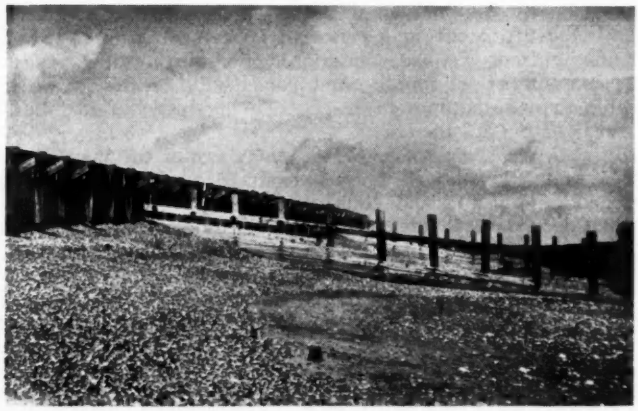


Fig 37. Stub groyne and wave breaker at Rye Bay. Note the shape of the shingle beach, and the sandy area in foreground.

The question then arises, what influenced the accretion in the first place and later what ended this and brought about depletion? My recollection is that Mr. Latham suggested a change in the cycle of the estuary regimen; that the mobile material was now attracted to the Welsh coast on the opposite side of the estuary. That is a broader view than the conditions warrant. It is much more probable that the causes were purely local, due to changes in the sea bed to the west and to the groyne constructed to the east; otherwise, improvement of beach building would not have been achieved by the new works. We will return to this point later.

Physical Considerations

It is impossible to fully appreciate the factors involved in Coast Protection without, at least, a general idea of coastal history. The science that deals with these matters is a combination of meteorology, geology, and oceanography, and is known as Physical Geography or Physiography. The world-wide research of the relevant matters provides one with a fund of information of the natural forces at work in the shaping of the shore-lines of land masses. The literature on the subject is extensive, nevertheless our purpose will be served if we recall a few of the main factors.

The Changing Coastline

Erosion. At all times there are in operation natural forces, atmospheric, gravitational, wind, and wave, which alter the contacting zone of land and water. They give rise to active physical change in the configuration of the shore line: rocky cliffs are attacked by rain, frost, wind, and wave, resulting in fractures of the mass, of which fragments are detached and hurled to the sea

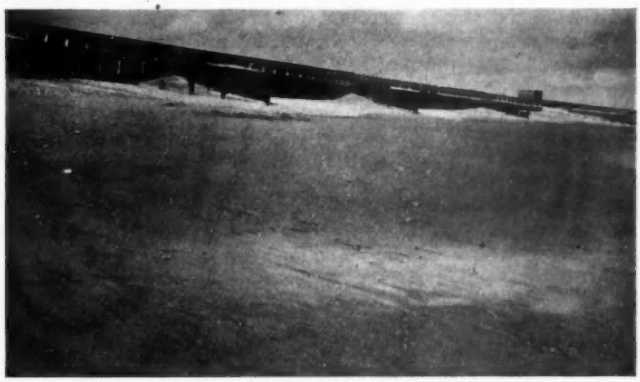


Fig. 38. Stub groynes in front of the wave breaker. A definite boundary line between shingle and sand, and a heaping up of shingle alongside groynes is clearly seen.

bed. There, the debris is pulverized and pounded to yet smaller fragments of which the beaches are composed.

There are, of course, movements of the earth's crust, some gradual and some catastrophic, but these, though noted, are beyond human interference. The more active agents of denudation over the interior of the land masses arise from wind, rain, snow, ice and weathering (which may be that of temperature changes only), have their effects on the coast line. The soil and the debris are collected in the natural land drainage systems, torrents, streams, rivers, and carried along these water courses to the sea. There they add to the fragmentary products of coast erosion forming mud bars or sand banks near to the rivers' mouths.

The erosion due to waves can be very severe, even in cliffs of hard rock, such as the igneous rocks of Scotland and Norway. In the softer rocks, as the chalk of Dover Cliffs (Fig. 2), and the coastline of Sussex, the erosive action is plainly visible. The waves, supplied with heavy ammunition in the form of rock fragments hurl these against the cliffs, biting into them most severely between the tide levels. The destructive effect of the waves operates through the mechanical channels of the expenditure of energy, of the moving mass of water, the bombardment of the rock face by projected rock lumps, the compression and expansion alternations of air pressure in rock crevices, and the hydraulic pressure of water forced, under impact, in cracks and crevices of the rock. The blows of these attacks take place during storms every 9 to 10 seconds, which is the average period of storm waves.

This violent action in the course of time wears away a notch in the rock face between tide levels. Thus there results a rock bench below low water and an overhanging rock above high water. Eventually under atmospheric and gravitational forces the overhanging portion falls into the sea, providing yet further ammunition for the ceaseless wave action.

Fig. 39. Migratory shingle spread over the lower sand beach in front of the wave breaker.

Coast Protection—continued

Constructive Effects. The work of the waves, however, does not always result in the recession of the coast, for the material, drawn from the cliffs, is ground up by the ceaseless rolling and buffeting action over the sea bed, and against other bodies, and it is then washed by the sea into indentations of the coast, or into some other shallower area, where the wave forces are not so severe. In the course of time these accumulations form beaches. On these beaches the grinding process of pebble reduction still goes on, producing sand particles which are washed away, in suspension in the agitated water, to find eventually, a temporary rest in sand banks or quieter beaches far distant from their origin.

These beaches forming an almost neutral state between supply and removal (accretion and depletion) are usually to be found as cresent-shaped embayments. Where the supply of mobile material, sand or shingle, is great, and is caused to move along the coast beyond some prominence into the sea, where the currents or waves to the lee are opposed to its direction of travel, the material is halted and a spit is formed. There are many examples in the British Isles, of which the better known are Hurst Castle Spit, Blakeney, Chichester and Orfordness. The point to note, about the formation and continued growth of these barriers, is the fact that the material which is halted at the spit is depleted from the beaches to the weather side, and denied to the beaches to the lee side. It also shows that a balance of natural forces may be wrought by the incidence of directed currents.

Fig. 40. Old piles closely spaced in front of wave breaker palisade.

The continued supply of material to these spits, and the inability of the transporting currents to prolong the ends into the sea against the opposing currents, causes the spit, after a time, to form a hooked end, or, as at Chichester, to regress landwards.

It will be gathered from the above that the general tendency of natural forces is to transform the indented coast into one following a straight line. The coast line of low-lying land is mostly regular, even if slightly curved, whereas high lands usually border deeply indented coast lines: the maps of the counties bordering the North Sea show this. The problems of Coast Protection are less difficult when dealing with accretion phenomena for this is more concerned with the maintenance of navigable channels than the safety of valuable property. In this connection it is interesting to note that fine sand when thrown up by the sea in quantity unless quickly planted with vegetation may eventually innundate large tracts of agricultural land.

Outstanding examples of this occur on the North Coast of Morayshire near Findhorn. The Culbin Sands, over the centuries, have accumulated in the crescentic bay to such an extent that under wind forces they have smothered large areas of the countryside: houses, farms, valleys and tall conifer forests were obliterated by an advancing sand-wave front of some 60-ft. high. The catastrophic advance of these sand waves can only be checked by the planting of bent or marram grass which, by their tangled root growth and coarse tufts, check the wind action on the surface grains. In the French Landes, on the Bay of Biscay, an even more difficult sand assault takes place, in which the action of the binding grasses has to be reinforced by the planting of conifers. The operations of planting to check advance are usually commenced from the sand wave front, that is the landward side and are then gradually extended to seaward. In this way the sand is held to the shore line and gradually brings about a retrogression of the high water line.

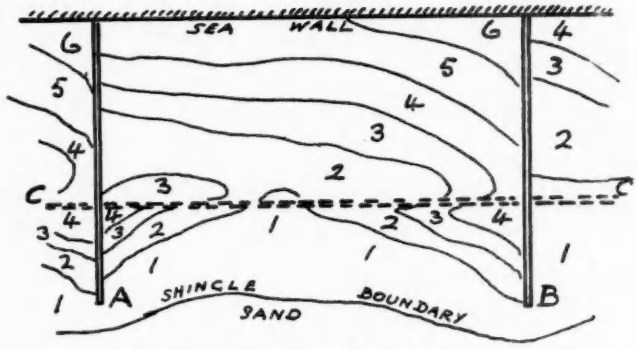


Fig. 41. Contours of shingle beach relative to sand line.

In this connection a most interesting fact regarding the advance of sand over deserts under wind action, though not entirely related to this subject, is the shape of the travelling dunes. In plan, these take the form of elongated crescents, called "barchans," and frequently occur in a series of clusters or groups with the advancing fronts on the concave side (inside) of the crescents. The contours of the mobile sand banks lying on the sea bed resemble these formations in reverse, having the elongated tips to the rear of the advance.

By and large, on rocky coasts, there is not the necessity for protection works, though in southern Italy, where some towns are perched on hillsides and cliffs along the coast they have been found necessary. Where habitations, towns, villages, etc., stretch down to the beach and on coasts of valuable low-lying lands protection works of some sort are required. Some of these latter are situated on coasts where the constructive work of the sea has been going on for generations and a large part of the land has been reclaimed for agriculture, or habitation, by man-made drainage and protection dykes. Here the sea continues to build up, but not at the rate to attain the equivalent slope artificially made by the protection dykes and works. The seas processes are gradual, whereas man-made works represent sudden and severe interference with natural mechanism. It is for this reason that the artificial beaches fronting coastal dykes, or banks, frequently higher than the agricultural ground to the landward, are subject to occasional depletion. The premature maturity makes them more vulnerable to the balancing mechanism of wind and wave forces.

When engineers were first engaged on Coast Protection works it would be difficult to say, but it is not without interest to note that

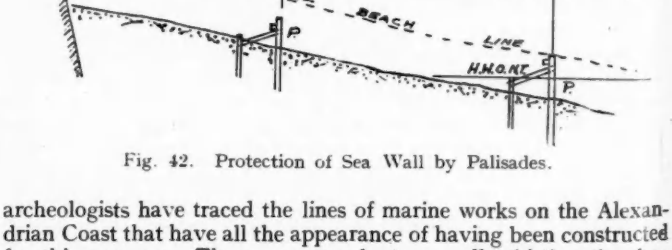


Fig. 42. Protection of Sea Wall by Palisades.

archeologists have traced the lines of marine works on the Alexandrian Coast that have all the appearance of having been constructed for this purpose. They were rough stone walls skirting the then line of beach, and, even to-day, an almost similar construction is used along the shores of the Mediterranean.

(To be continued)

Dover Harbour Board

Excerpts from Administration Report for Financial Year ended March, 1948

General Review

The year under review has generally proved to be a satisfactory one. Following the chaotic conditions which existed at the end of the War, definite strides towards revival were made during 1947. There was a distinct improvement in trade, considerable progress achieved in rehabilitation, and signs in every direction of the gradual return of normal peace-time activities.

The various Companies and Users of the port made a substantial contribution towards this end. The Board for their part concentrated on repair work, which included the removal of the war-time defence structures and obstructions, at the same time endeavouring to provide better facilities for working areas at the quay sides, improve road access and generally tidy up. The removal of obsolete and dilapidated structures and gear also received attention. The work under this head proved to be considerable, but was essential to the better interests of economy and efficiency.

Finance

After making due provision for taxation, the year under review has resulted in an excess of expenditure over income of £5,399, as compared with an excess of expenditure over income in the previous year of £5,867.

These deficits are due to abnormal expenditure incurred in deferred works and maintenance programme following the War period and have been met out of the balance of net revenue account carried forward.

Revenue: The estimated budget revenue put forward totalled £244,300 against which the revenue earned accumulated to £255,494.

Expenditure: The expenditure for the year amounted to £260,893 against a budget provision of £244,750.

General: The provision of the budget estimates with the relative supporting progressive revenue and expenditure returns has greatly assisted every-day operation and management. This is only the second year that a budget has been provided, but the results have proved satisfactory. Actual expenditure or revenue compares favourably with the estimates, and where differences arise, there are good reasons which were not apparent when the budget estimates were prepared. More important is the fact that the financial control now operating permits of constant adjustment throughout the year in order to meet changed conditions as they arise.

Shipping and Trade

A total of 3,089 vessels entered the port during the year with a net registered tonnage of 2,100,000 compared with 2,426 vessels of 1,880,000 n.r. tons for the previous year.

The number of cars passing through the port during the year totalled 36,000 compared with 10,000 the previous year.

Abnormally heavy passenger traffic was the rule at the end of July and early August, during which period the Dover-Ostend services were duplicated. The total number of passengers, other than military personnel, passing through the port was 830,000 compared with 465,000 for the previous year.

The influence of the international economic or political situation at various times on passenger travel and car traffic has a strong bearing on the trade of this port and is a matter which cannot be overlooked. It is essential, therefore, to foster other resources to meet such fluctuations. It is important not to rely on trade which is principally pleasure travel, especially when there are many other ports along this coast which cater almost entirely for such trade.

The volume of cargo passing through the port during the year showed a slight increase but still falls very short of the tonnage for an average year pre-war. The total tonnage for the year under review accumulated to just under 400,000 tons compared with 320,000 tons for the previous year. Actually, the volume of tonnage exported fell short of the previous year's figures, but with the improved facilities being provided at the Granville Dock for coastal trade it is anticipated that this traffic will gradually improve.

Maintenance

The total works undertaken during the year amounted to £100,000 (including war damage repairs). The principal items of maintenance work, etc., carried out were as follows:—

Admiralty Pier. The important work in this area is that of fender piling, which had to be more or less stripped during the War. When the question of replacement was considered, attention was directed to an improved design for these Cross-channel berths, and after consultation with the railways a new lay-out has been formulated.

These fenders are subject to very heavy wear and the object was to double up the fenders and concentrate the piling at the most vital points. Attention has also been given to a new design of buffer pile.

Great difficulty has been experienced in the supply of suitable material, particularly timber. Completion of the permanent work is, however, anticipated during the current year.

Prince of Wales Pier. The second half of the viaduct portion of the pier was repaired and repainted, and war damage repairs were carried out to the viaduct structure.

Inner Docks. The Wellington Dock gates were removed and slipped for thorough overhaul and repair. At the same time the masonry work at the dock entrance, including the gate recesses, control and operating gear and machinery were thoroughly overhauled. Advantage was taken during this period to clear the dock of debris and obstructions and to effect fairly extensive war damage repairs to the quay walls.

Sea Front. The work of steel sheet piling at the sea front retaining wall to below chalk level was completed in accordance with programme. The work was put in hand to counteract erosion in this area. The loss of beach is a matter of constant concern and minor remedies are continually being carried out. Attention has been directed to the repair and replacement of groynes. The difficulty, of course, is that the existing sea wall for some considerable length was built on the beach which requires consolidation to chalk level where the drift takes place.

Eastern Docks. The approach to the Eastern Docks was improved by the removal of the dilapidated timber fencing which was replaced with a mild steel fencing.

Necessary repairs were carried out to the main wall faces of jetties and spacing blocks were re-positioned. A new steel signal mast was erected at the end of the Eastern Arm and repairs were effected to services, roads, fences, etc.

Dredging. The Admiralty dredging craft continued dredging in the Outer Harbour during the year. On the 1st April, 1947, a balance of 940,900 cub. yds. of silt remained to be removed. Certain areas were completed during the year and at the end of the financial year the balance had been reduced to 480,000 cub. yds. It is hoped to complete this dredging during the current year.

The Board's dredging plant was engaged in the Camber and at the Eastern Arm and Prince of Wales Pier berths, also in the Wellington Dock. A total quantity of 34,000 cub. yds. was dredged. At the request of the British Railways, the Board undertook a small quantity of dredging within the Ferry Dock area.

The provision of an Echo Sounding equipment has greatly assisted in the surveys, which are required as a matter of regular routine and especially in connection with dredging.

Proposed New Bridge at the Port of Belfast.

The Belfast Corporation Improvement Committee has now adopted the recommendation that the new crossing of the River Lagan should be a high level bridge north of the Queen's Bridge, and an approach will be made to the Government for financial assistance. The recommendation is that of a sub-committee of the Corporation, the Harbour Board, and the Northern Ireland Government. It is designed to provide freer access to berths at Donegal and Queen's Quays, and to help the working of the dockside railway.

Notes of the Month

Belfast Harbour Power Station.

Belfast Corporation is to apply to the Ministry of Commerce for sanction to raise a loan of £1,817,860 to cover the cost of plant extensions at the Harbour Power Station. This was decided at a special meeting of the Electricity Committee, held towards the end of last month, when the reports of the City Electrical Engineer and Consulting Engineer were adopted.

Increased Trade at South Wales Ports.

The trade of the South Wales ports of Cardiff, Swansea, Newport, Barry, Port Talbot and Penarth from 1st January to 28th November, 1948, was over 3,000,000 tons greater than in the corresponding period of 1947, the cargo handled being 12,409,946 tons, compared with 9,331,425 tons a year ago. Imports amounted to 4,724,557 tons, compared with 4,017,317 tons, and exports were 7,676,389 tons against 5,314,108 tons. A total of 14,430 vessels of 8,523,696 tons net, used the ports, while in the same period of 1947 the figures were 12,978 and 7,442,996 tons respectively.

Improved Cargo-Handling Facilities at Port of Melbourne.

The turn-round of ships in the Port of Melbourne should be appreciably speeded up as the result of plans agreed between the Harbour Trust and the Waterside Workers' Uuion. The Board proposes to spend over £100,000 in improving the cargo-handling facilities, including the installation of four of the latest type of electric cranes capable of a 3-ton lift, and also a number of mobile cranes which are being made in England. The Waterside Workers' Federation has arranged to admit another 400 men into the union and they should begin work this month.

Development Plans at the Port of Auckland.

A big development scheme for the Port of Auckland has been adopted by the Harbour Board in co-ordination with the Auckland Metropolitan Planning Organisation. Provisional plans provide for the construction of two large wharves and several smaller quays, and tor the transfer of oil tank installations from the city. The new site to be developed will be capable of providing more berthage than the whole of the present commercial wharves, and ships will enter the port extension by passing under a harbour bridge which is to be built in connection with the scheme. The estimated cost of the project is over £5,000,000.

New Chairman for Port of Liverpool.

Mr. Edmund Gardner, for eight years deputy-chairman of the Mersey Docks and Harbour Board, was recently elected chairman of the board in succession to Sir Thomas Brocklebank. At the meeting, the retiring chairman, when proposing Mr. Gardner's name tor election as chairman, paid tribute to his valuable work during his eight years as deputy-chairman. Colonel J. G. B. Beazley, who has previously been chairman of the marine committee and the observatory committee of the board, was elected deputy-chairman. During the war he was chairman of the port emergency committee and of the executive committee of the Dock and Harbour Authorities' Association.

New Oil Refinery at Antwerp.

The Anglo-Iranian Oil Company, Ltd., and Compagnie Financière Belge des Pétroles (Petrofina), S.A., have announced their joint agreement to the construction of an oil refinery at Antwerp. They propose to form a company, Société Industrielle Belge des Pétroles, S.A., registered in Belgium, in which they will each hold an equal interest, to construct and operate the refinery on a site of approximately 150 hectares leased from the Port of Antwerp. A petroleum dock and turning basin will be constructed by the port to accommodate the extra traffic, which will include large-size modern oil tankers, The refinery will have an initial intake capacity of 30,000 barrels of crude oil per day, and will ultimately give employment to about 1,000 persons. Construction will begin early this year, and it is anticipated that the new installation will be in operation in 1951-52.

Rochdale Canal to be Closed.

Subject to obtaining the necessary Parliamentary powers, the 35 miles long Rochdale Canal, with the exception of about two miles in Manchester, is to be closed for navigation purposes. The section to be kept open connects the Bridgwater and Ashton Canals and carries a good deal of coal and timber. All other services, such as water supply to the many mills along the banks, will continue on the length it is proposed to close for navigation.

Port of Newry Improvement Plans.

Newry Urban Council and the Port and Harbour Trust have decided to ask the consulting engineers to include in their proposals for an harbour improvement scheme, plans for the building of new wharves outside the entrance to the inland canal so that ships of 4,000 tons could trade direct to Newry. It was stated that because of rock obstruction in Carlingford Lough vessels entering the port would be limited to 4,000 tons. The consulting engineers are to report to a further joint meeting, when a deputation will be appointed to approach the Ministry of Commerce regarding a grant. The total cost of the scheme is expected to be about £80,000.

Trial of Mersey Dredger.

With reference to the account of the electrically-operated crane grab dredger Mersey No. 26, which appeared in the October, 1948, issue of this Journal, when the vessel was engaged on her trials on the Clyde, the " Journal of Commerce " has drawn attention to several interesting features. One of these was the operating speed of the grab buckets on being dropped into the water. When the buckets were lifted clear of the water they were completely full and the level top of the spoil in each was noticeable, indicating that the buckets were taking a clean " bite " from the bottom. When the spoil reached the surface there was little of the usual spill of water, not only proving the solidity of the material moved, but also the tightness of the bucket fittings. As it is desired to use this vessel tor dock dredging, where the major portion of the material to be handled is silt, large perforated plates are fitted over the ship's hopper in the positions where the three crane grabs discharge; they are providel primarily to salve any materials of value which may be lifted from the dock floors. It is understood that on occasions quite a quantity of valuable metal and other merchandise which has slipped from a sling or otherwise been dropped is retrieved when the various docks have their periodic clean-up.

FOR SALE.

ELECTRIC CABLE in stock: 8 large drums, 3 core, .6 sq. in. section each core, Heavy Cab Tyre, Trailing Cable, flexible, 3½-ins. overall diameter—total 1,200 yds. New from factory, at about half price; suitable for heavy outdoor work, export, etc. Also Paper Insulated Cables and other smaller sizes from stock. Also 300 large Straight Through Joint Boxes. 'Phone Portsmouth 31730, or write: The Cable & Electrical Supply Co., 28, Wimbledon Park Road, Southsea, Hants.

TENDERS.

DEPARTMENT OF DEFENCE, DUBLIN.
TENDERS FOR DREDGING.

In view of the introduction of amendments to the specification for the above mentioned work, the Minister for Defence has extended the latest date for receiving sealed tenders to noon on the 19th January, 1949.

Tender forms, specification and conditions of contract may be had on application to the Secretary, Department of Defence (S4E), Parkgate, Dublin.

PEADAR MacMATHGHAMHNA (Secretary).

SITUATIONS VACANT.

CIVIL ENGINEERING DRAUGHTSMEN required by Samuel Williams & Sons, Ltd., for work at their Dagenham Dock Estate and in connection with clients' factories in the Greater London area. Applicants should be first-class draughtsmen with sound experience of survey work, including use of level and theodolite. A good salary is offered to a suitable man and the appointment is pensionable. Assistance will be given in obtaining a house, if required. Write: Personnel Manager, Samuel Williams & Sons, Ltd., Dagenham Dock, Essex.